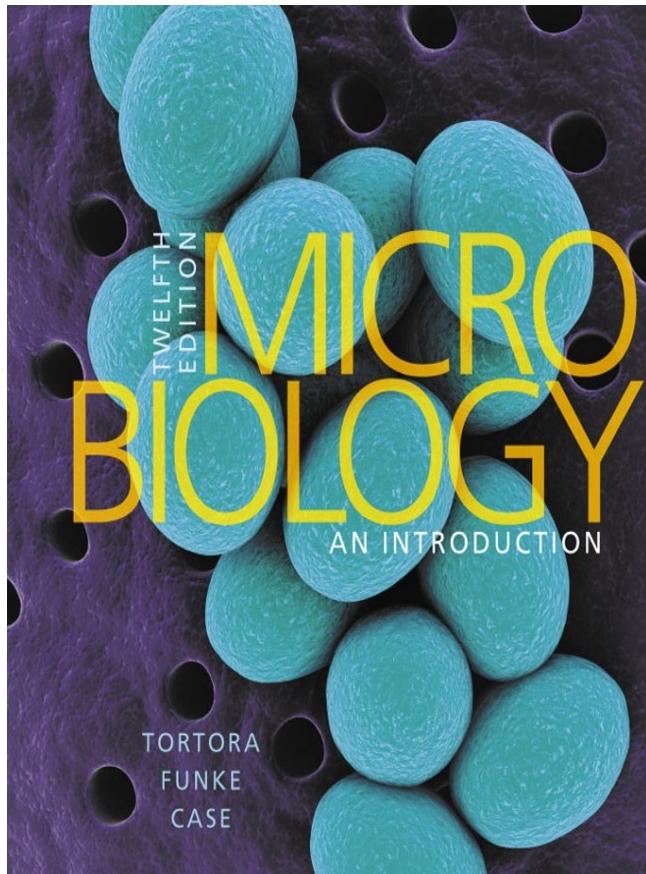


# **Microbiology an Introduction**

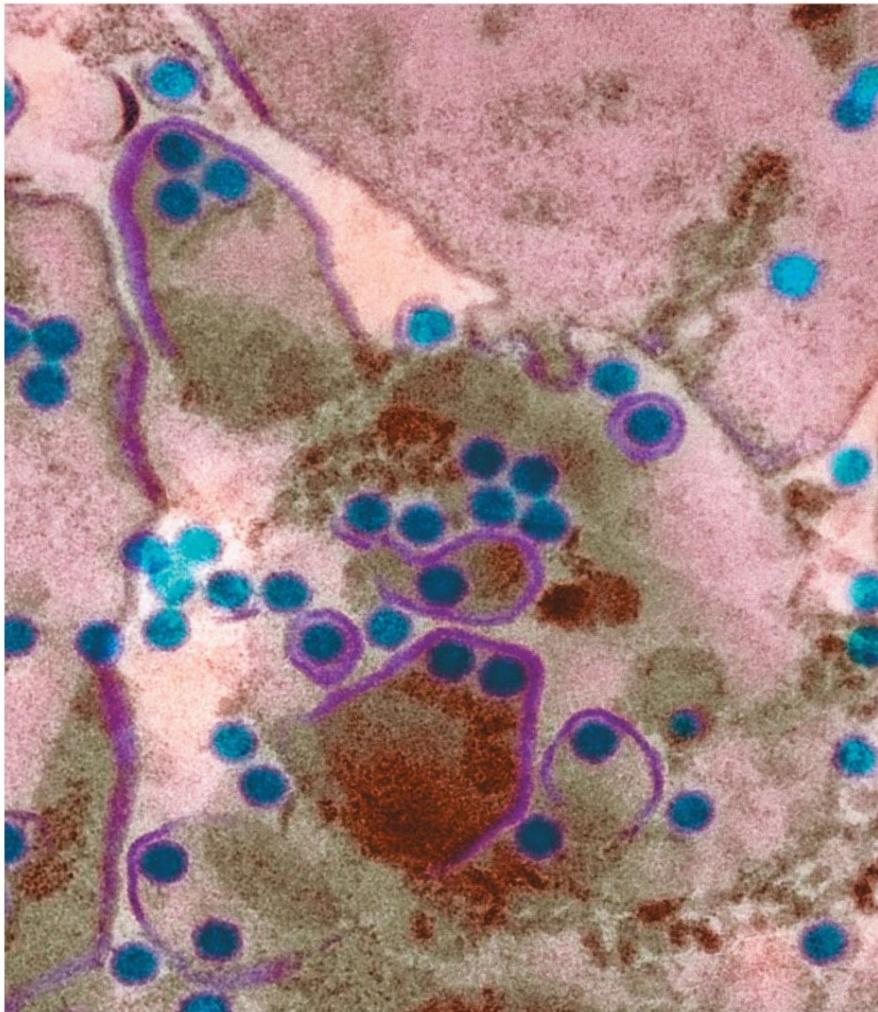
Twelfth Edition



## **Chapter 23**

### **Microbial Diseases of the Cardiovascular and Lymphatic Systems**

# Dengue Virus (Blue) Cells



# **Structure and Function of the Cardiovascular and Lymphatic Systems (1 of 3)**

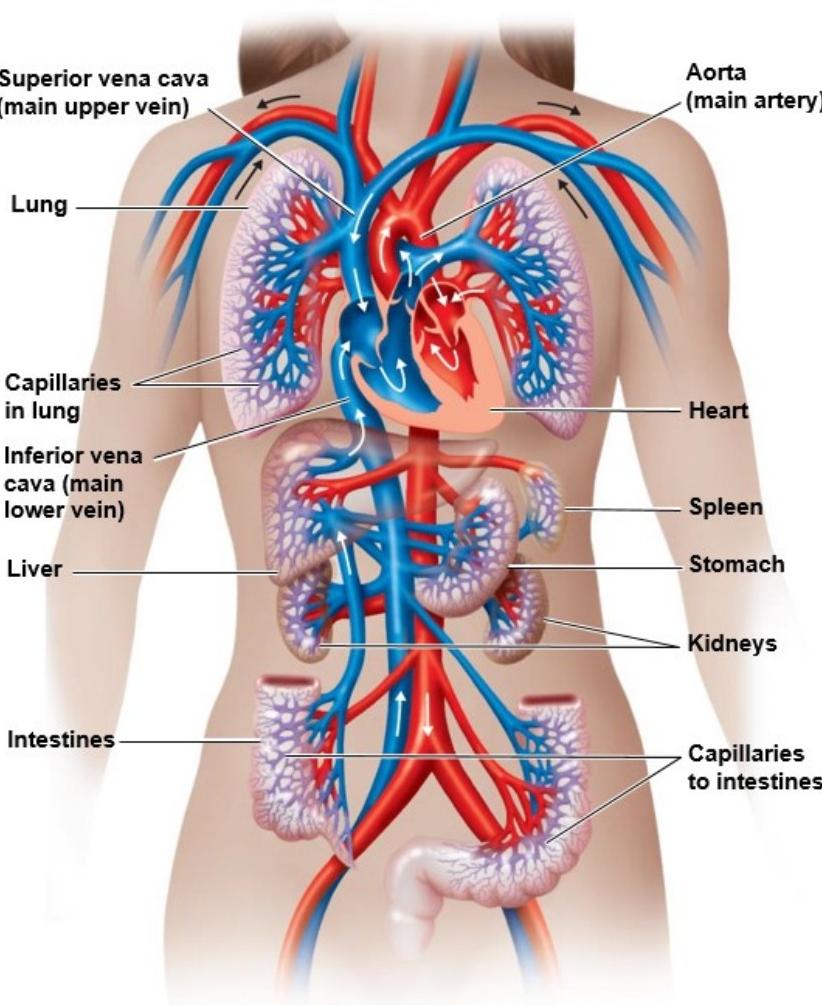
## **Learning Objective**

23-1 Identify the role of the cardiovascular and lymphatic systems in spreading and eliminating infections.

# Structure and Function of the Cardiovascular and Lymphatic Systems (2 of 3)

- **Cardiovascular system:** circulates blood through the body's tissues
  - Includes the heart and associated arteries, veins, and capillaries
  - Delivers substances to and removes substances from the cells

# Figure 23.1 The Human Cardiovascular System and Related Structures

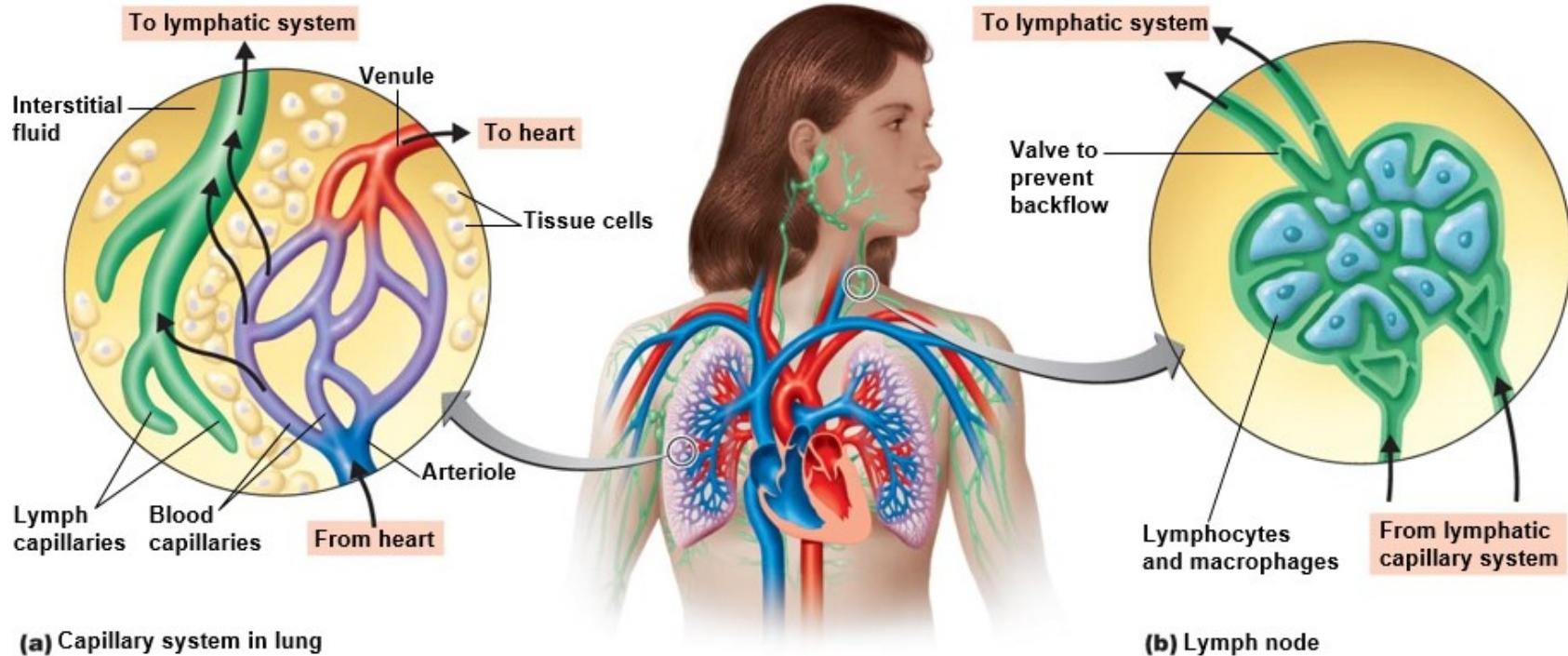


# Structure and Function of the Cardiovascular and Lymphatic Systems (3 of 3)

- **Lymphatic system**

- Plasma leaves blood capillaries to become interstitial fluid
- Lymph capillaries transport interstitial fluid (lymph) to lymph vessels (lymphatics) and lymph nodes
  - Picks up microorganisms and infectious agents
- Lymph nodes contain fixed macrophages, B cells, and T cells
  - **Buboes:** swollen lymph nodes

# Figure 23.2 The Relationship Between the Cardiovascular and Lymphatic Systems



# **Check Your Understanding-1**

## **Check Your Understanding**

- ✓ Why is the lymphatic system so valuable for the working of the immune system?

23-1

# **Bacterial Diseases of the Cardiovascular and Lymphatic Systems (1 of 3)**

## **Learning Objectives**

- 23-2 List the signs and symptoms of sepsis, and explain the importance of infections that develop into septic shock.
- 23-3 Differentiate gram-negative sepsis, gram-positive sepsis, and puerperal sepsis.
- 23-4 Describe the epidemiologies of endocarditis and rheumatic fever.
- 23-5 Discuss the epidemiology of tularemia.

# **Bacterial Diseases of the Cardiovascular and Lymphatic Systems (2 of 3)**

## **Learning Objectives**

- 23-6 Discuss the epidemiology of brucellosis.
- 23-7 Discuss the epidemiology of anthrax.
- 23-8 Discuss the epidemiology of gas gangrene.
- 23-9 List three pathogens that are transmitted by animal bites and scratches.

# **Bacterial Diseases of the Cardiovascular and Lymphatic Systems (3 of 3)**

## **Learning Objectives**

- 23-10 Compare and contrast the causative agents, vectors, reservoirs, symptoms, treatments, and preventive measures for plague, Lyme disease, and Rocky Mountain spotted fever.
- 23-11 Identify the vector, etiology, and symptoms of five diseases transmitted by ticks.
- 23-12 Describe the epidemiologies of epidemic typhus, endemic murine typhus, and spotted fevers.

# **Sepsis and Septic Shock**

- **Septicemia**
  - Acute illness due to the presence of pathogens or their toxins in the blood
- **Sepsis**
  - Systemic inflammatory response syndrome (SIRS)
- **Lymphangitis**
  - Inflamed lymph vessels
- **Severe sepsis**
  - Decreased blood pressure and dysfunction of at least one organ
- **Septic shock**



# Figure 23.3 Lymphangitis, One Sign of Sepsis



# Gram-Negative Sepsis (1 of 2)

- Also called endotoxin shock
- Endotoxins (lipopolysaccharides [LPS]) cause a severe drop in blood pressure
- Antibiotics can worsen the condition by killing bacteria
- Treatment involves neutralizing the LPS components and inflammatory-causing cytokines

# Gram-Negative Sepsis (2 of 2)

- Potent exotoxins that cause toxic shock syndrome
- Hospital-acquired infections
  - **Enterococcus faecium** and **Enterococcus faecalis**
    - Inhabit the colon
    - Colonize wounds and the urinary tract
    - Resistant to many antibiotics
  - **Group B streptococci (GBS)**
    - **Streptococcus agalactiae**
      - Neonatal sepsis

# Puerperal Sepsis

- Also called **puerperal fever** and **childbirth fever**
  - Caused by **Streptococcus pyogenes**
  - Transmitted to the mother during childbirth
    - Infects the uterus and progresses to an infection of the abdominal cavity (peritonitis)

# **Check Your Understanding-2**

## **Check Your Understanding**

- ✓ What are two of the conditions that define the systemic inflammatory response syndrome of sepsis?

23-2

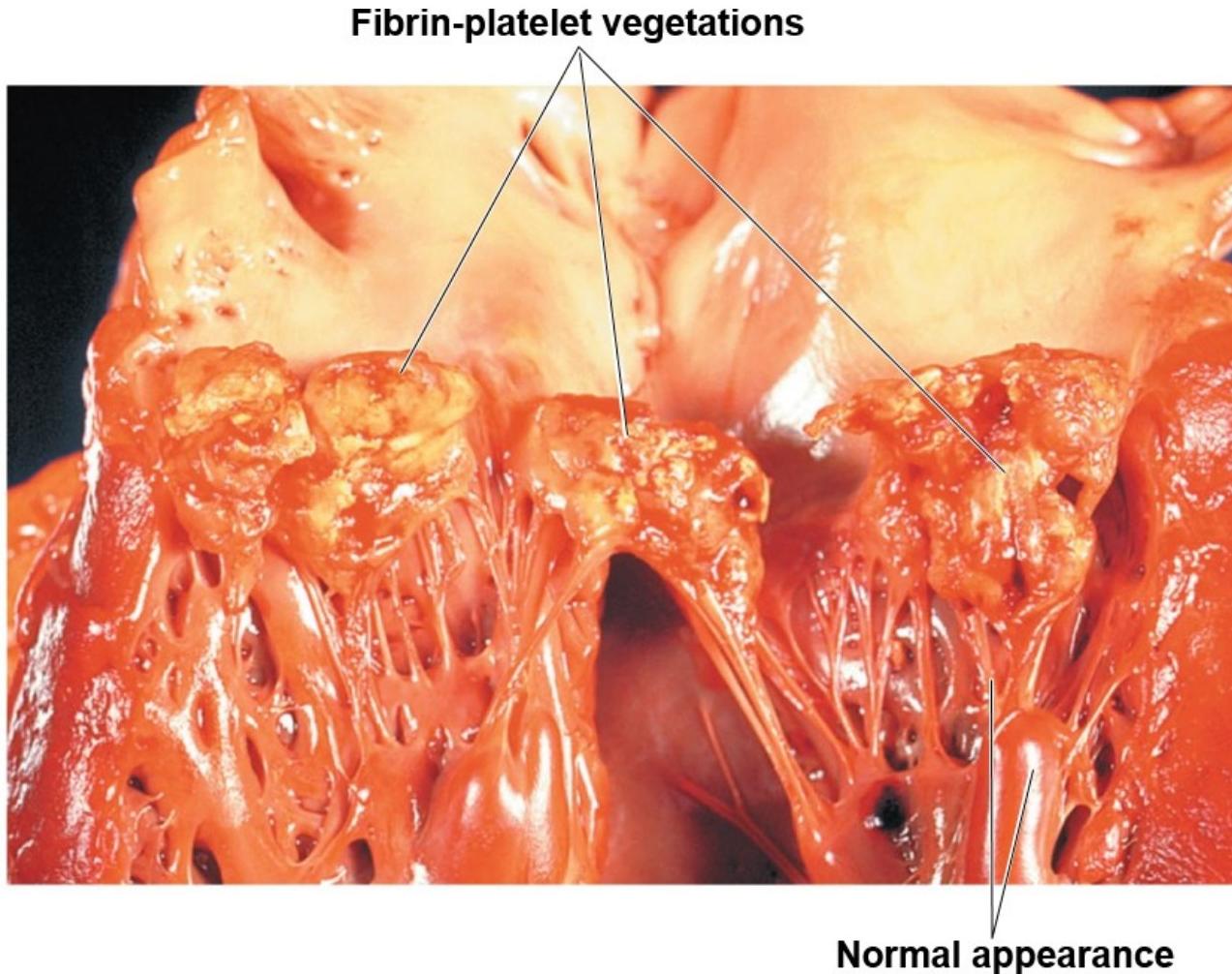
- ✓ Are the endotoxins that cause sepsis from gram-positive or gram-negative bacteria?

23-3

# Bacterial Infections of the Heart

- **Endocarditis**
  - Inflammation of the endocardium
- **Subacute bacterial endocarditis**
  - Impairs the function of the heart valves
  - Alpha-hemolytic streptococci from an oral or tonsil infection
- **Acute bacterial endocarditis**
  - Caused by **Staphylococcus aureus**
- **Pericarditis**
  - Inflammation of the sac around the heart
  - Streptococci

# Figure 23.4 Bacterial Endocarditis



# **Check Your Understanding-3**

## **Check Your Understanding**

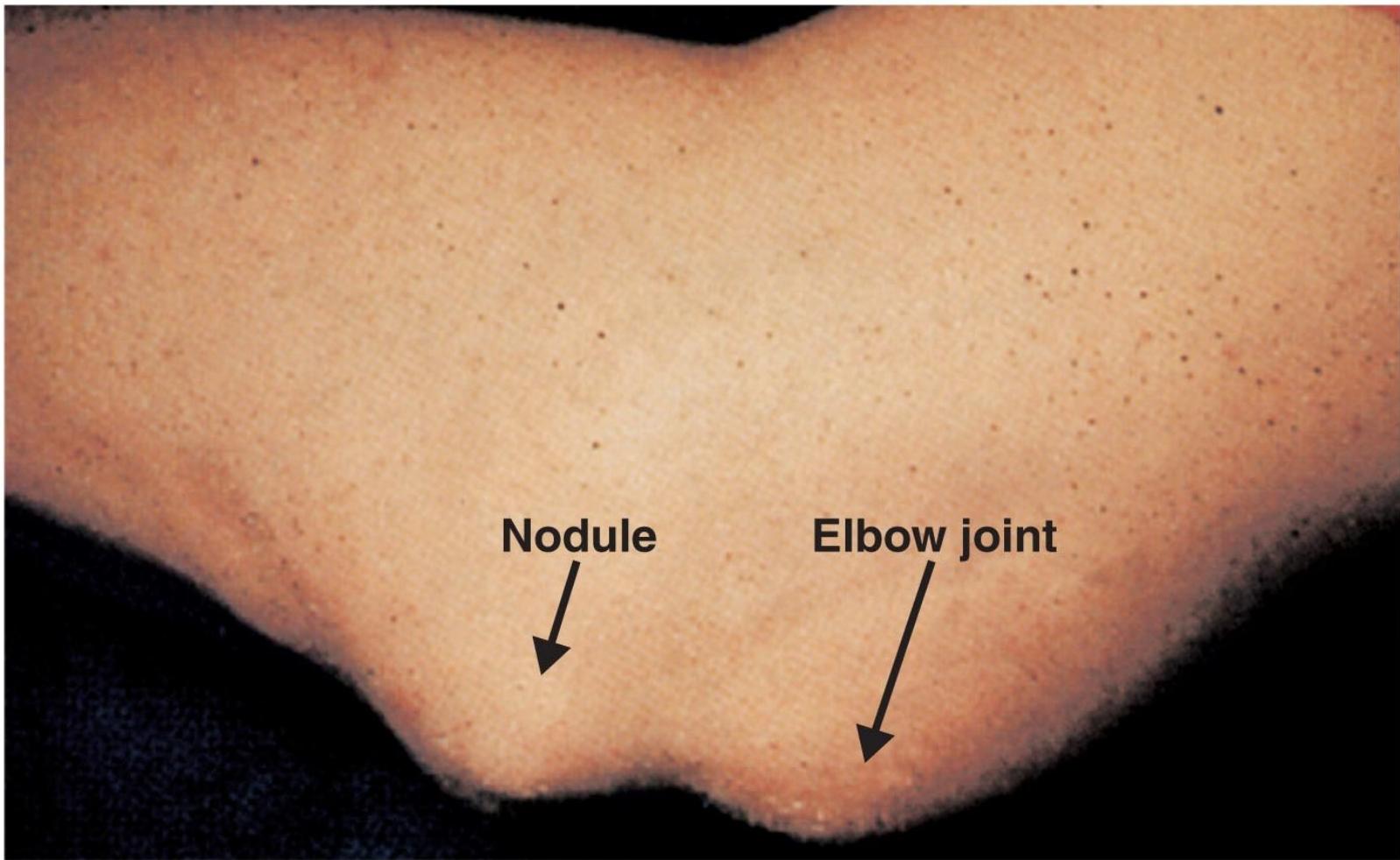
- ✓ What medical procedures are usually the cause of endocarditis?

23-4

# Rheumatic Fever

- Autoimmune complication of **S. pyogenes** infections
- Inflammation of the heart valves
  - Immune reaction against streptococcal M protein
- Subcutaneous nodules at the joints
- **Sydenham's chorea**
  - Purposeless, involuntary movements

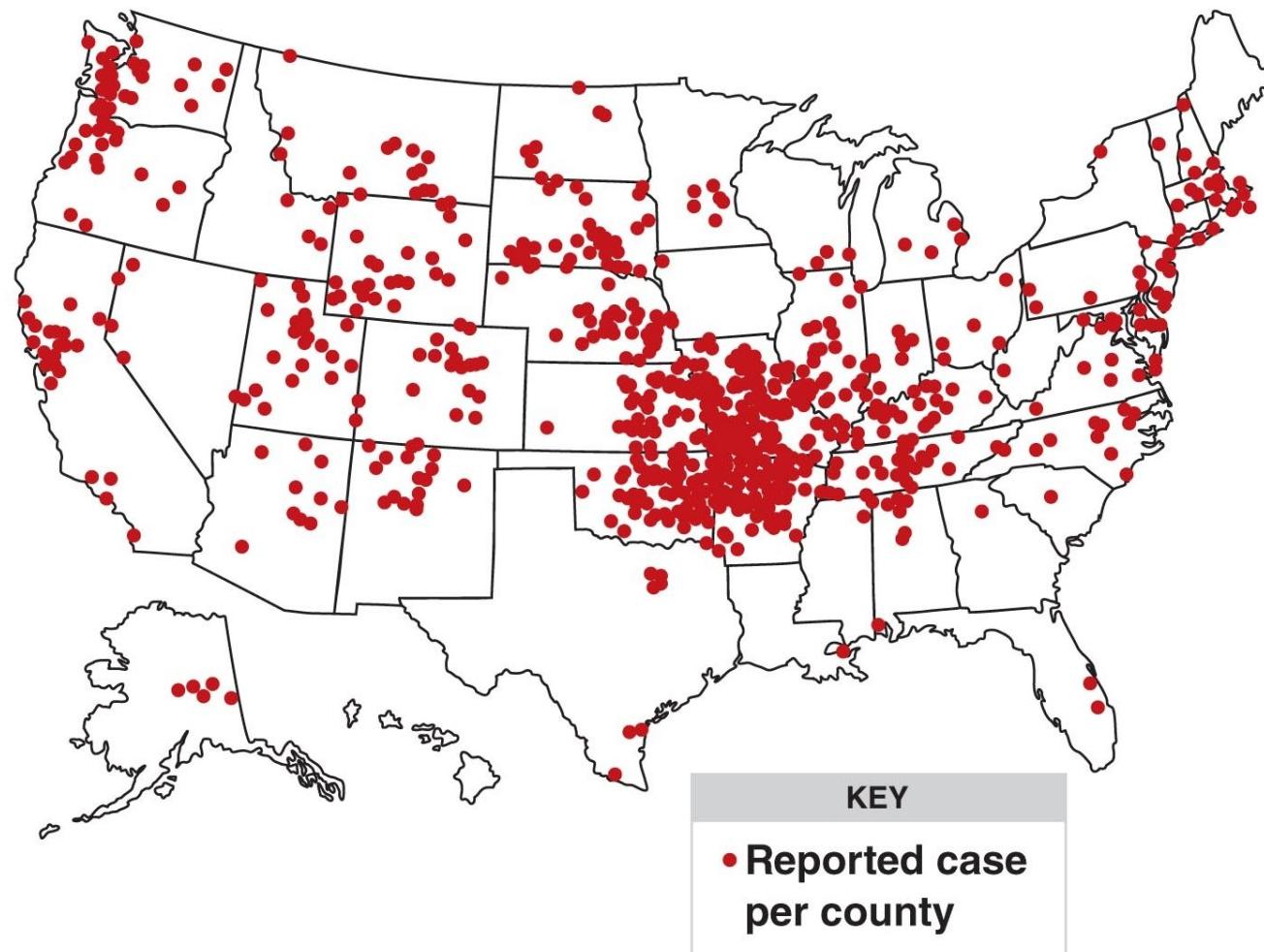
# Figure 23.5 A Nodule Caused by Rheumatic Fever



# Tularemia

- Caused by **Francisella tularensis**
  - Gram-negative rod
- Zoonotic disease
- Transmitted from rabbits, ticks, and insects by deer flies
- Creates an ulcer at the site of entry
- Bacteria reproduce in phagocytes
  - Enlarges the regional lymph nodes
- Mortality usually < 30%

# Figure 23.6 Tularemia cases in the United States (2001-2010)



# **Check Your Understanding-4**

## **Check Your Understanding**

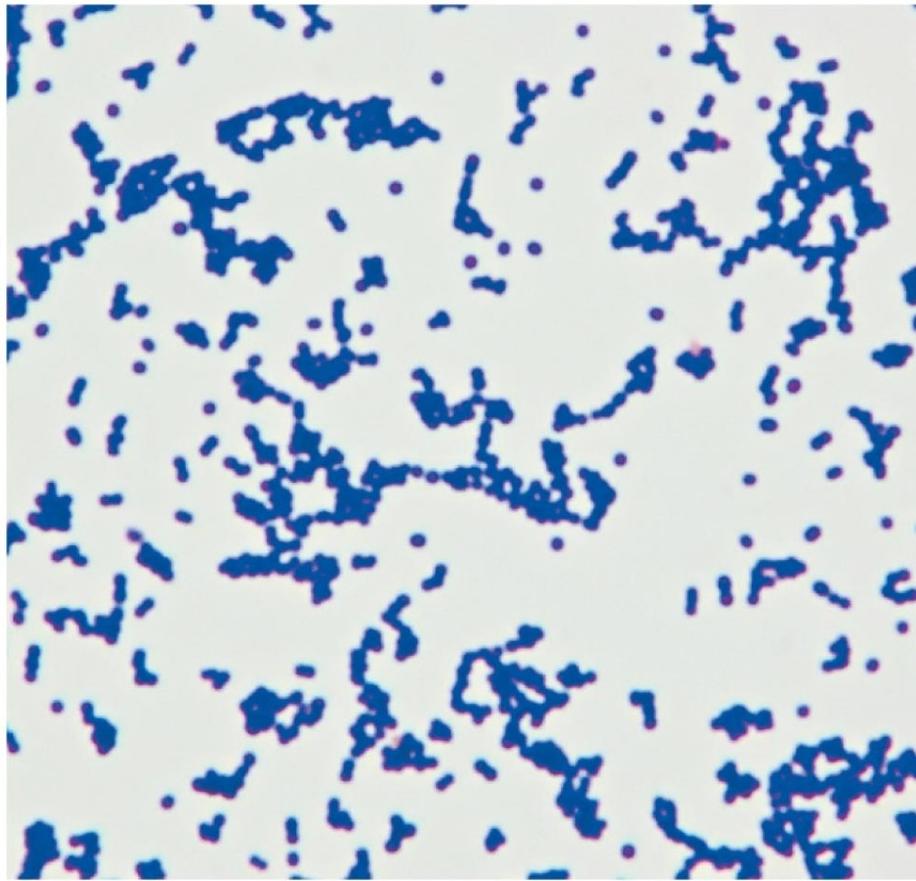
- ✓ What animals are the most common reservoir for tularemia?

23-5

# Diseases in Focus: Infections from Human Reservoirs

- A 27-year-old woman has a fever and cough for 5 days. She is hospitalized when her blood pressure drops. Despite aggressive treatment with fluids and massive doses of antibiotics, she dies 5 hours after hospitalization. Catalase-negative, gram-positive cocci are isolated from her blood.
- What infections could cause these symptoms?

# Diseases in Focus 23.1 (1 of 3)



LM

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# Diseases in Focus 23.1 (2 of 3)

Disease	Pathogen	Symptoms	Reservoir	Method of Transmission	Treatment
<b>BACTERIAL DISEASES</b>					
<b>Septic Shock</b>	Gram-negative bacteria, enterococci, group B Streptococci	Fever, chills, increased heart rate; lymphangitis	Human body	Injection; catheterization	Antibiotics
<b>Puerperal Sepsis</b>	<b>Streptococcus pyogenes</b>	Peritonitis; sepsis	Human nasopharynx	Nosocomial	Penicillin
<b>Endocarditis Subacute Bacterial Acute Bacterial</b>	Mostly alpha-hemolytic streptococci; <b>Staphylococcus aureus</b>	Fever, general weakness, heart murmur; damage to heart valves	Human nasopharynx	From focal infection	Antibiotics
<b>Pericarditis</b>	<b>Streptococcus pyogenes</b>	Fever; general weakness; heart murmur	Human nasopharynx	From focal infection	Antibiotics
<b>Rheumatic Fever</b>	Group A beta-hemolytic streptococci	Arthritis, fever; damage to heart valves	Immune reactions to streptococcal infections	Not transmissible	Supportive. Prevention: penicillin to treat streptococcal sore throats

# Diseases in Focus 23.1 (3 of 3)

Disease	Pathogen	Symptoms	Reservoir	Method of Transmission	Treatment
<b>VIRAL DISEASES</b>					
<b>Burkitt's Lymphoma</b>	Epstein-Barr (EB) virus	Tumor	Unknown	Unknown	Surgery
<b>Infectious Mononucleosis</b>	EB virus	Fever, general weakness	Humans	Saliva	None
<b>Cytomegalovirus</b>	Cytomegalovirus	Mostly asymptomatic; initial infection acquired during pregnancy can be damaging to fetus	Humans	Body fluids	Ganciclovir, fomivirsen
<b>UNKNOWN ETIOLOGY</b>					
<b>Kawasaki Syndrome</b>	Unknown	Fever, rash, coronary artery abnormalities	Unknown	Unknown	None

# Brucellosis (Undulant Fever)

- **Brucella** spp.
  - Aerobic gram-negative rods
  - **Brucella abortus** (elk, bison, cows)
  - **Brucella suis** (swine)
  - **Brucella melitensis** (goats, sheep, camels)
- Transmitted via milk from infected animals or contact with infected animals
- Perists in the reticuloendothelial system; evades phagocytes
- Undulant fever (malaise, night sweats, muscle aches)



# **Check Your Understanding-5**

## **Check Your Understanding**

- ✓ What ethnic group in the United States is most commonly affected by brucellosis, and why?  
23-6

# Anthrax (1 of 3)

- Caused by **Bacillus anthracis**
  - Gram-positive, endospore-forming aerobic rod
- Found in soil
- Primarily affects grazing animals
- Spores introduced into the body are taken up by macrophages and germinate
  - Bacteria enter the bloodstream and release toxins
- Treated with ciprofloxacin or doxycycline

# Anthrax (2 of 3)

- Bacteria produces virulence factors
  - Protective antigen: binds the toxins to target cells, permitting their entry
  - Edema toxin: causes local swelling and interferes with phagocytosis
  - Lethal toxin: targets and kills macrophages
  - Amino acid capsule that avoids an immune response

# Anthrax (3 of 3)

- **Cutaneous anthrax**

- Endospores enter through a minor cut
  - 20% mortality rate without treatment

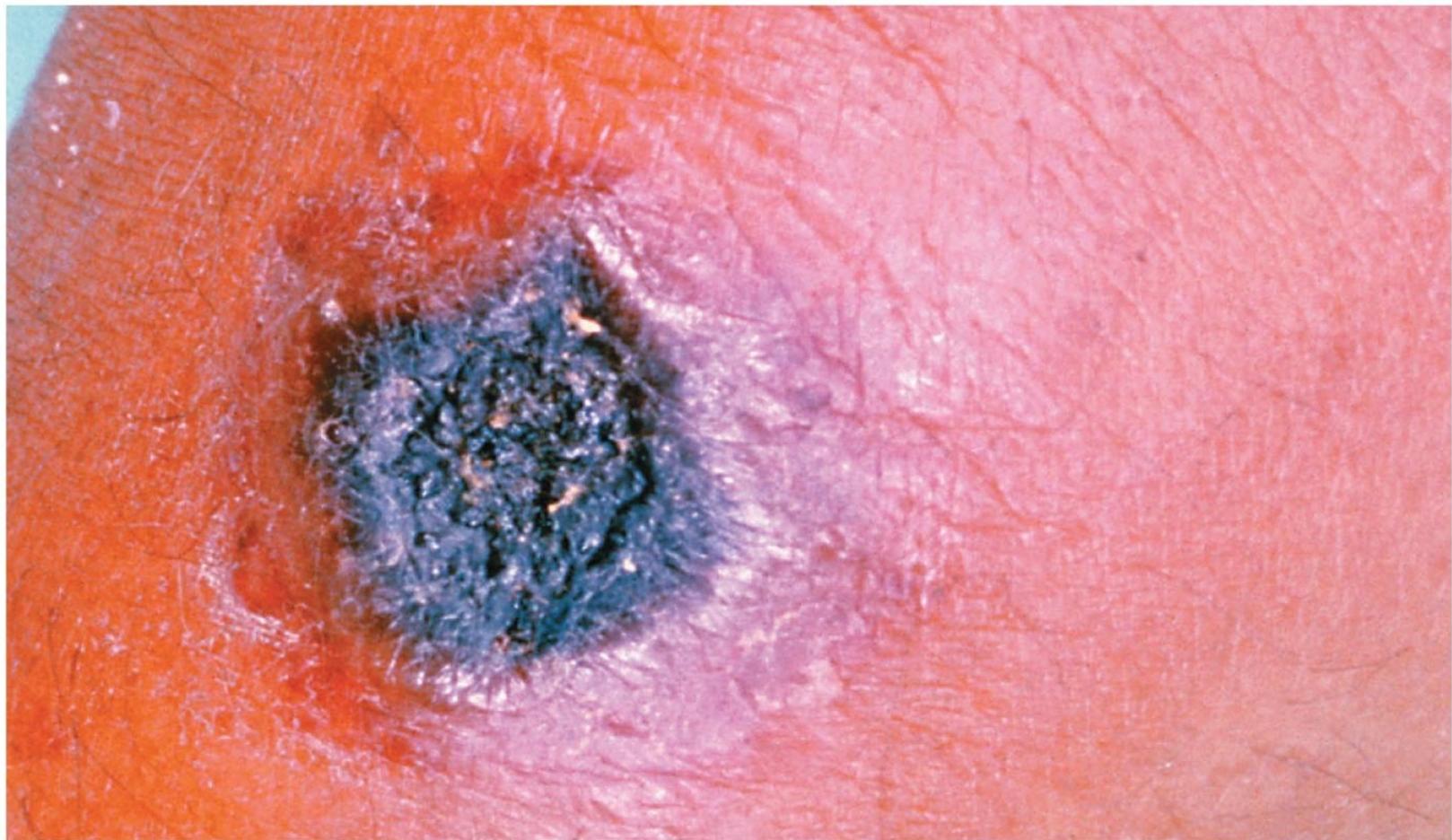
- **Gastrointestinal anthrax**

- Ingestion of undercooked, contaminated food
  - 50% mortality rate

- **Inhalational (pulmonary) anthrax**

- Inhalation of endospores
  - Bacteria enter the bloodstream; progresses into septic shock
  - Near 100% mortality rate

## Figure 23.7 Anthrax Lesion



# **Check Your Understanding-6**

## **Check Your Understanding**

- ✓ How do animals such as cattle become victims of anthrax?

23-7

# Applications of Microbiology: Protection against Bioterrorism

- 1346: plague-ridden bodies used by the Tartar army against Kaffa (Ukraine)
- 1937–1945: plague-carrying flea bombs used in the Sino-Japanese War
- 1979: explosion of **B. anthracis** weapons plant in the Soviet Union
- 1984: **Salmonella enterica** used against the people of The Dalles, Oregon
- 1996: **Shigella dysenteriae** used to contaminate food
- 2001: **B. anthracis** distributed in the United States



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# Applications of Microbiology

## 23.2

Bacteria	Viruses
<b>Bacillus anthracis</b>	Arenaviruses
<b>Brucella</b> spp.	Hantavirus, encephalitis viruses
<b>Chlamydophila psittaci</b>	Hemorrhagic fever viruses (Ebola, Marburg, Lassa)
<b>Clostridium botulinum toxin</b>	Monkeypox
<b>Coxiella burnetii</b>	Nipah virus
<b>Francisella tularensis</b>	Smallpox
<b>Rickettsia prowazekii</b>	
<b>Shigella</b> spp.	
<b>Vibrio cholerae</b>	
<b>Yersinia pestis</b>	

# Gangrene

- **Ischemia:** loss of blood supply to tissue
- **Necrosis:** death of tissue
- **Gangrene:** death of soft tissue
- **Gas gangrene**
  - Caused by **Clostridium perfringens**, a gram-positive, endospore-forming anaerobic rod
    - Grows in necrotic tissue
    - Produces toxins that move along muscle bundles
  - Treatment includes the surgical removal of necrotic tissue and/or use of a **hyperbaric chamber**

# Figure 23.8 The Toes of a Patient with Gangrene



# **Check Your Understanding-7**

## **Check Your Understanding**

- ✓ Why are hyperbaric chambers effective in treating gas gangrene?

23-8

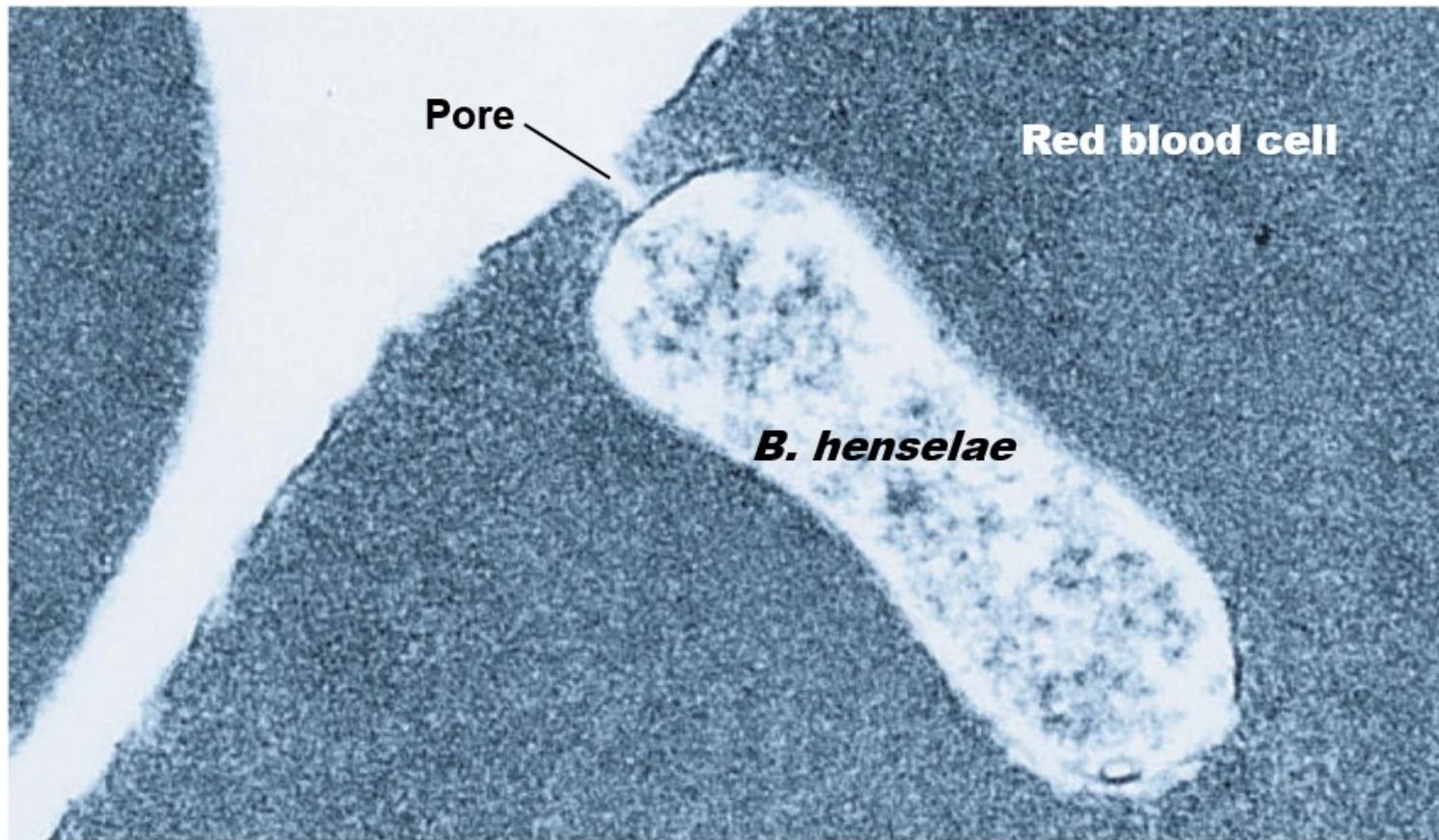
# Systemic Diseases Caused by Bites and Scratches

- 1% of ER visits
- Dogs make up 80% of reported bites; cats about 10%
  - Cat bites have higher infection rates
- **Pasteurella multocida**
  - Gram-negative rod; causes sepsis
- **Staphylococcus, Streptococcus, Corynebacterium**

# Cat-Scratch Disease

- Caused by **Bartonella henselae**
  - Aerobic, gram-negative
  - Inhabits cat RBCs; carried in the blood of 50% of cats
  - Multiplies in the digestive system of cat fleas
    - Cat claws contaminated with flea feces scratch human
- Forms a papule at the infection site and swollen lymph nodes
- Self-limiting

# Figure 23.9 Electron Micrograph Showing the Location of *Bartonella henselae* Within a Red Blood Cell.



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# Rat-Bite Fever

- Transmitted via rat bites
- Streptobacillary rat-bite fever
  - Found in North America
  - Caused by **Streptobacillus moniliformis**
    - Filamentous, gram-negative, pleomorphic, fastidious
    - Fever, chills, muscle pain; mortality rate of 10%
- Spirillar fever
  - Caused by **Spirillum minus**
  - Similar to streptobacillary rat-bite fever

# Check Your Understanding-8

## Check Your Understanding

- ✓ **Bartonella henselae**, the pathogen of cat-scratch disease, is capable of growth in what insect?  
23-9

# Diseases in Focus: Infections from Animal Reservoirs Transmitted by Direct Contact

- A 10-year-old girl is admitted to a local hospital after having fever ( $40^{\circ}\text{C}$ ) for twelve days and back pain for 8 days. Bacteria cannot be cultured from tissues. She has a recent history of dog and cat scratches. She recovers without treatment.
- What infections could cause these symptoms?

## Diseases in Focus 23.2 (1 of 3)



# Diseases in Focus 23.2 (2 of 3)

Disease	Pathogen	Symptoms	Reservoir	Method of Transmission	Treatment
<b>BACTERIAL DISEASES</b>					
Brucellosis	<b>Brucella</b> spp.	Local abscess; undulating fever	Grazing mammals	Direct contact	Tetracycline, streptomycin
Anthrax	<b>Bacillus anthracis</b>	Papule (cutaneous); bloody diarrhea (gastrointestinal); septic shock (inhalational)	Soil; large grazing mammals	Direct contact; ingestion; inhalation	Ciprofloxacin; doxycycline
Animal Bites	<b>Pasteurella multocida</b>	Local infection; sepsis	Animal mouths	Dog/cat bites	Penicillin
Rat-Bite Fever	<b>Streptobacillus moniliformis, Spirillum minus</b>	Sepsis	Rats	Rat bites	Penicillin
Cat-Scratch	<b>Bartonella</b>	Prolonged fever	Domestic	Cat bites or flea bites	Antibiotics

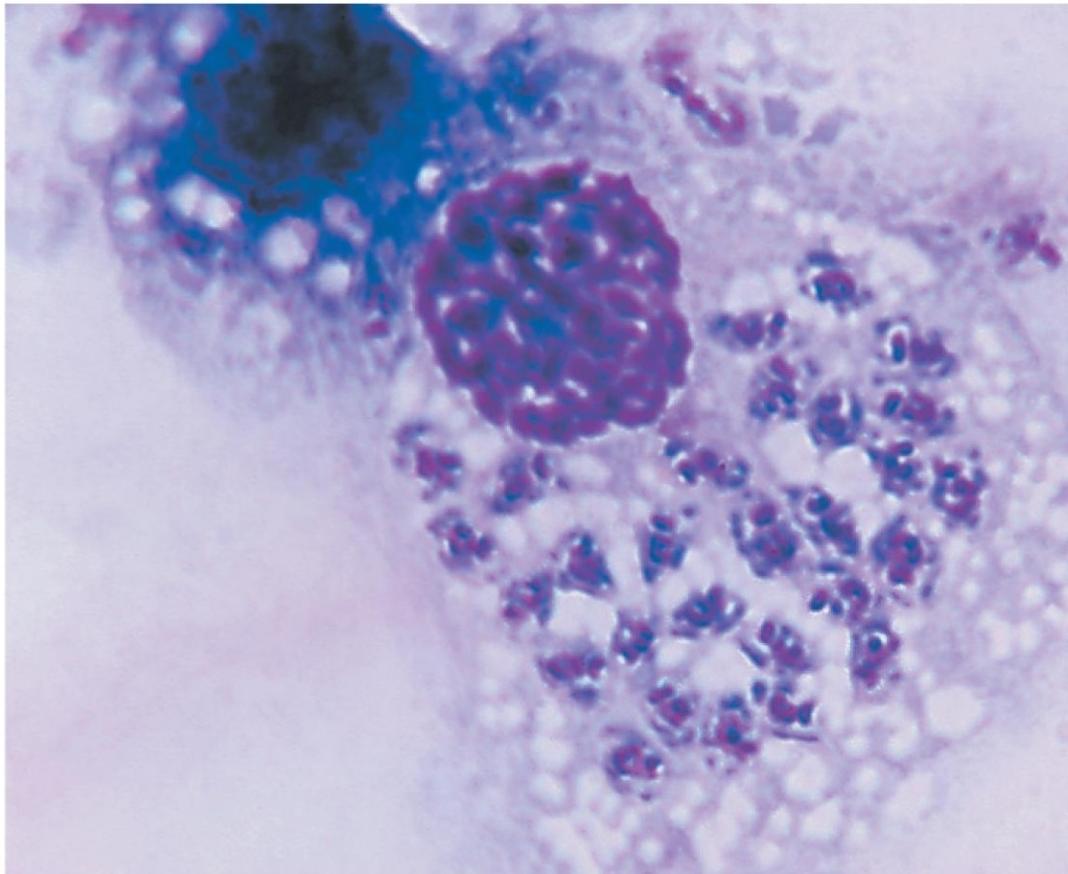
# Diseases in Focus 23.2 (3 of 3)

PROTOZOAN DISEASE					
Toxoplasmosis	<b>Toxoplasma gondii</b>	Mild disease; initial infection acquired during pregnancy can be damaging to fetus; serious illness in AIDS patients	Domestic cats	Ingestion	Ingestion Pyrimethamine, sulfadiazine and folinic acid

# Diseases in Focus: Infections Transmitted by Vectors

- A 22-year-old soldier returning from a tour of duty in Iraq has three painless skin ulcers. She reports being bitten by insects every night. Ovoid, protozoa like bodies, are observed within her macrophages by examination with a light microscope.
- What infections could cause these symptoms?

# Diseases in Focus 23.3 (1 of 3)



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# Diseases in Focus 23.3 (2 of 3)

Disease	Pathogen	Symptoms	Reservoir	Method of Transmission	Treatment
<b>BACTERIAL DISEASES</b>					
Tularemia	<b><i>Francisella tularensis</i></b>	Local infection; pneumonia	Rabbits; ground squirrels	Direct contact with infected animals, deer fly bite; inhalation	Tetracycline
Plague	<b><i>Yersinia pestis</i></b>	Enlarged lymph nodes; septic shock	Rodents	Fleas; inhalation	Streptomycin; tetracycline
Relapsing Fever	<b><i>Borrelia</i> spp.</b>	Series of fever peaks	Rodents	Soft ticks	Tetracycline
Lyme Disease	<b><i>Borrelia burgdorferi</i></b>	Bull's-eye rash; neurologic symptoms	Field mice	<b><i>Ixodes</i></b> ticks	Antibiotics
Ehrlichiosis and Anaplasmosis	<b><i>Ehrlichia</i> spp. <i>Anaplasma</i> spp.</b>	Flulike	Deer	<b><i>Ixodes</i></b> ticks	Tetracycline
Typhus Fever	<b><i>Rickettsia prowazekii</i></b>	High fever, stupor, rash	Squirrels	<b><i>Pediculus humanus corporis</i></b> louse	Tetracycline; chloramphenic ol
Endemic Murine Typhus	<b><i>Rickettsia typhi</i></b>	Fever; rash	Rodents	<b><i>Xenopsylla cheopis</i></b> flea	Tetracycline; chloramphenic ol
Rocky Mountain Spotted Fever	<b><i>Rickettsia rickettsii</i></b>	Macular rash; fever;	Ticks;	<b><i>Dermacentor</i></b> tick	Tetracycline

# Diseases in Focus 23.3 (3 of 3)

Disease	Pathogen	Symptoms	Reservoir	Method of Transmission	Treatment
<b>VIRAL DISEASE</b>					
<b>Chikungunya Fever</b>	Chikungunya virus	Fever; joint pain	Humans	<b>Aedes</b> mosquito	Supportive
<b>PROTOZOAN DISEASES</b>					
<b>Chagas' Disease (American Trypanosomiasis)</b>	<b>Trypanosoma cruzi</b>	Damage to heart muscle or peristaltic movement of gastrointestinal tract	Rodents, opossums	Reduviid bug	Nifurtimox
<b>Malaria</b>	<b>Plasmodium</b> spp.	Fever and chills at intervals	Humans	<b>Anopheles</b> mosquito	Malarone, artemisinin
<b>Leishmaniasis</b>	<b>Leishmania</b> spp.	<b>L. donovani:</b> systemic disease; <b>L. tropica:</b> skin sores; <b>L. braziliensis:</b> disfiguring damage to mucous Membranes	Small mammals	Sandfly	Antimony compounds
<b>Babesiosis</b>	<b>Babesia microti</b>	Fever and chills at intervals	Rodents	<b>Ixodes</b> ticks	Atovaquone and azithromycin

# Plague (1 of 2)

- Caused by ***Yersinia pestis***
  - Gram-negative rod
  - Transmitted by the rat flea (***Xenopsylla cheopis***)
  - Endemic to rats, ground squirrels, and prairie dogs
- Bacteria blocks the flea's digestive tract
  - Flea bites the host and ingested blood is regurgitated into the host
- Bacteria enter the bloodstream and proliferate in the lymph tissue
  - Cause intense swellings called buboes



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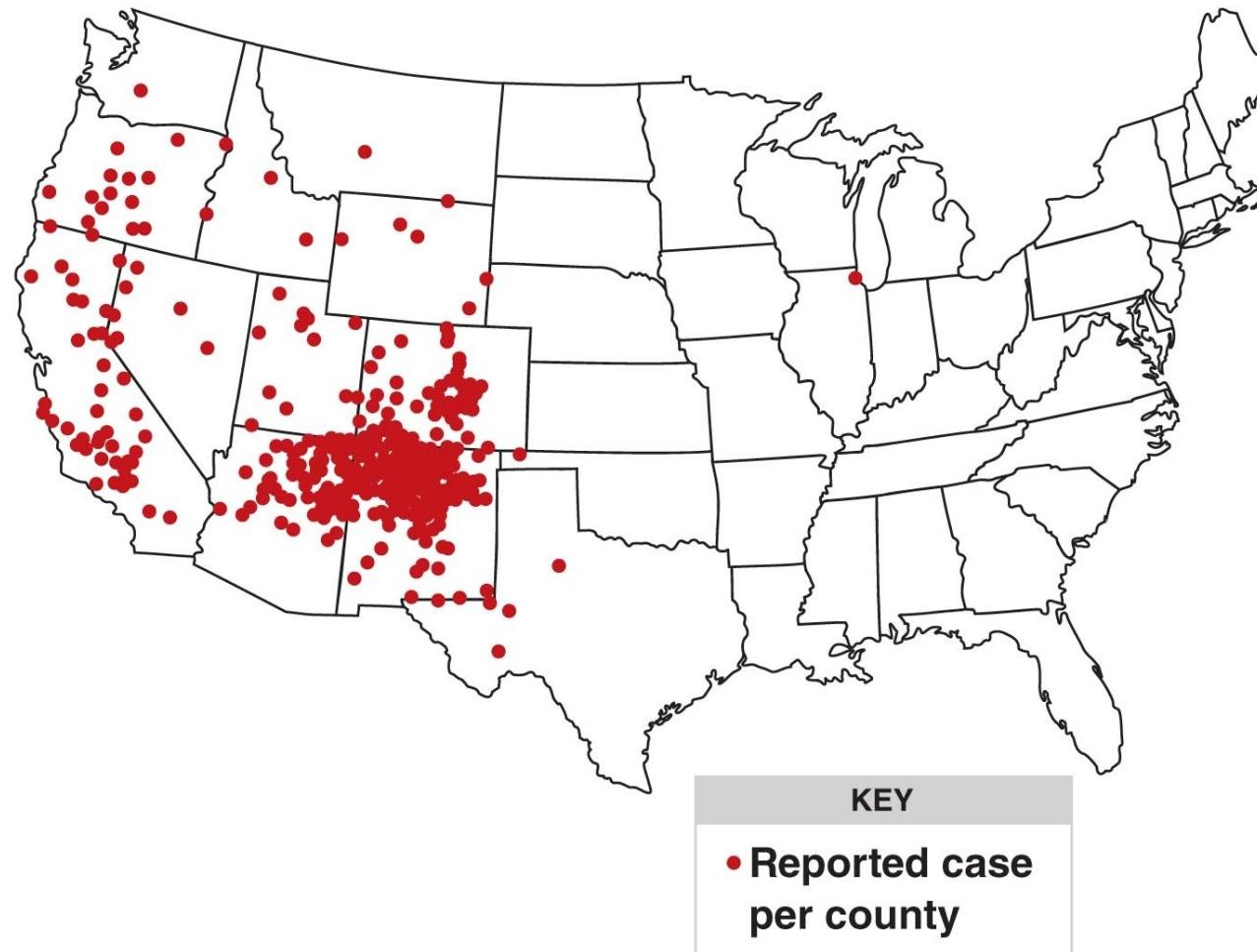
# Plague (2 of 2)

- **Bubonic plague**
  - Bacterial growth in the blood and lymph
  - Most common form; 50–75% mortality rate
- **Septicemic plague**
  - Septic shock due to bacteria in the blood
- **Pneumonic plague**
  - Bacteria in the lungs
  - Easily spread by airborne droplets
  - Near 100% mortality rate
- Antibiotic prophylaxis for exposure

# Figure 23.10 A Case of Bubonic Plague



# Figure 23.11 The U.S. geographic distribution of human plague, 1970-2012



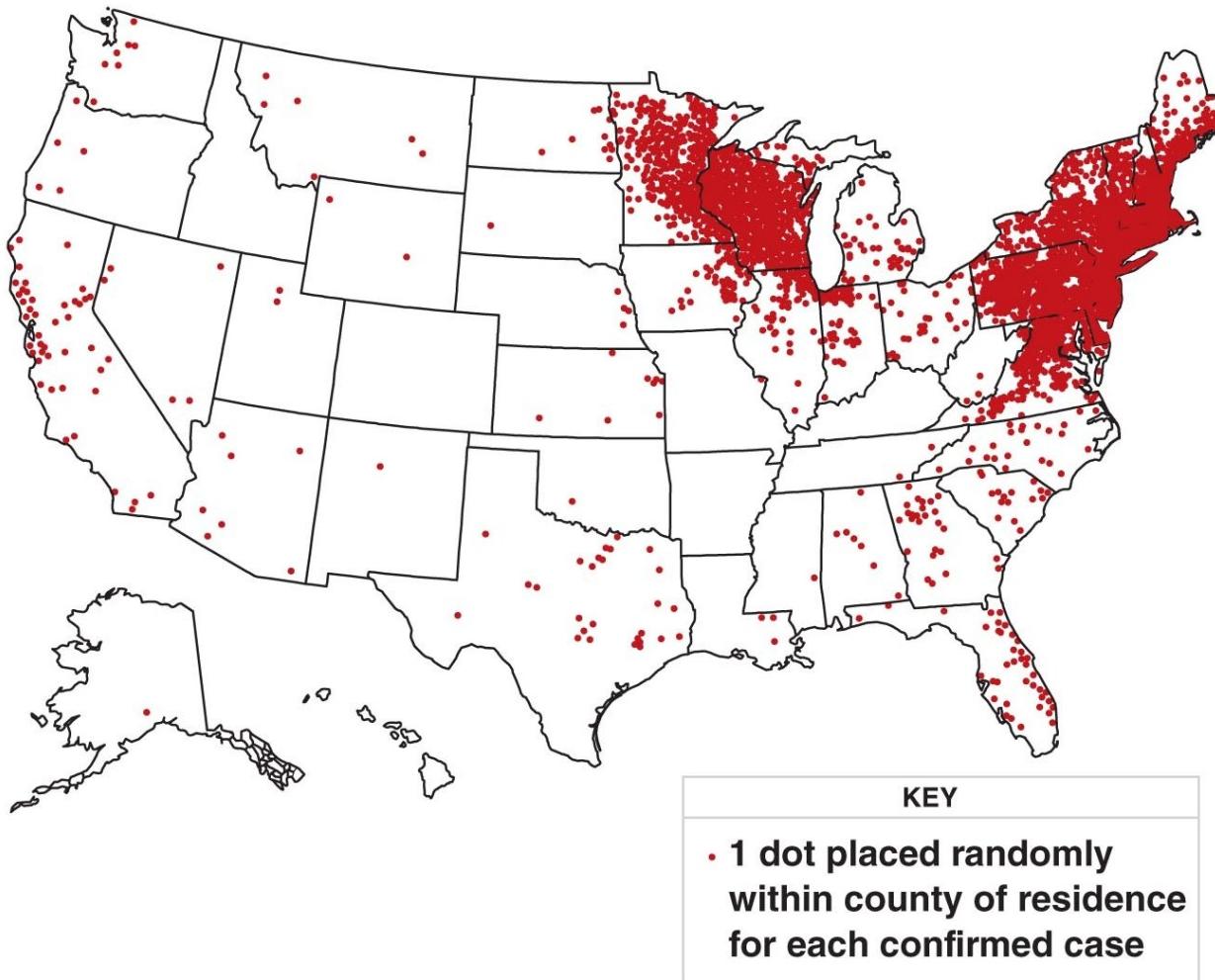
# Relapsing Fever

- Caused by **Borrelia** spp.
  - Spirochete
- Transmitted by soft ticks that feed on rodents
- High fever, jaundice, rose-colored skin spots
- Successive relapses are less severe
- Treated with tetracycline

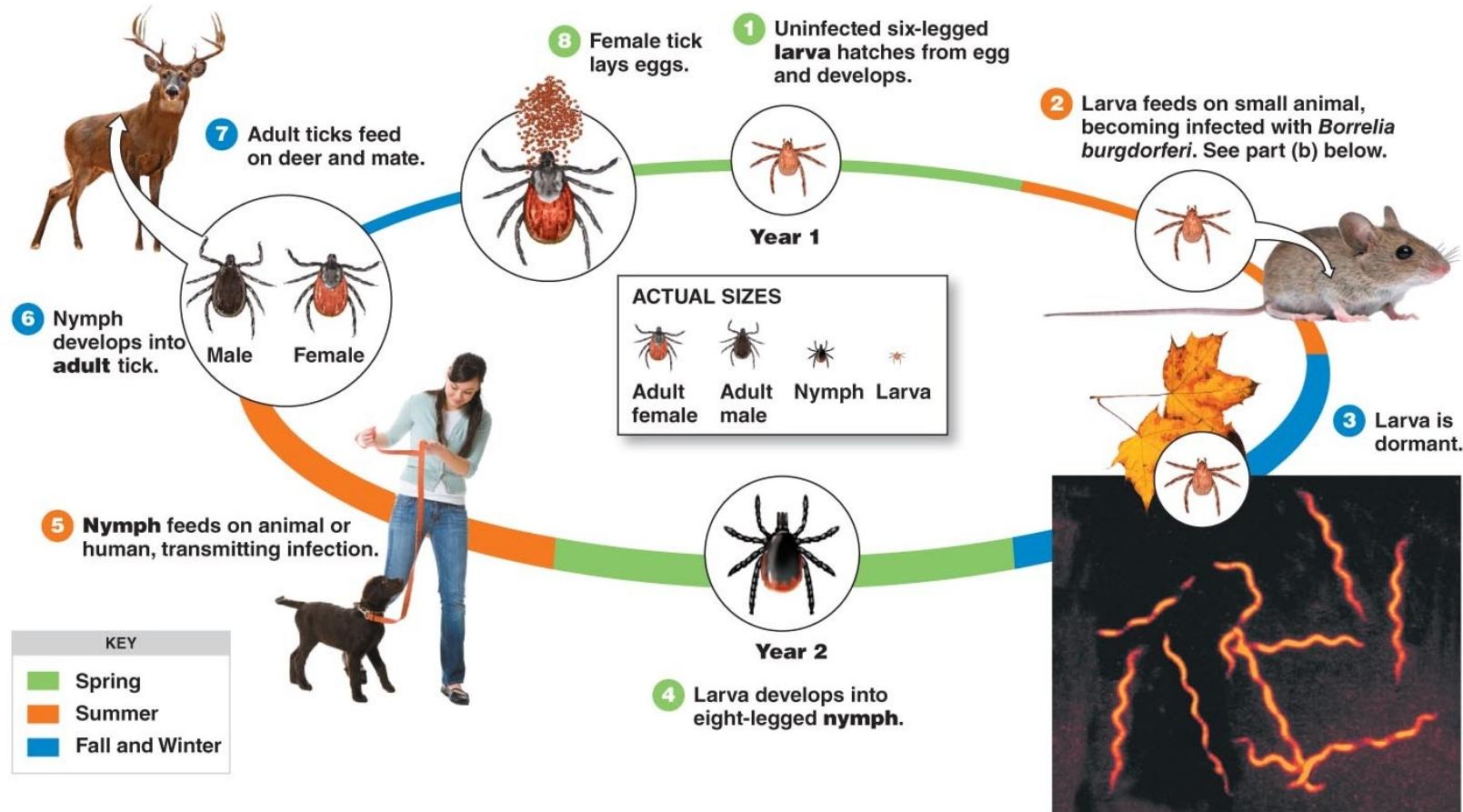
# Lyme Disease (Lyme Borreliosis) (1 of 2)

- Caused by **Borrelia burgdorferi**
- Most common tickborne disease in the United States
- Field mice are the most common reservoir
  - Nymphal stage of the **Ixodes** tick feeds on mice and infects humans
- Ticks feed on deer, but are not infected
- Ticks must attach two to three days to transfer bacteria

# Figure 23.12 Lyme Disease in the United States, Reported Cases by County, 2012



# Figure 23.13 The Life Cycle of the Tick Vector of Lyme Disease



**(b) The cause of Lyme disease, *Borrelia burgdorferi*** SEM 5 μm

# Lyme Disease (Lyme Borreliosis) (2 of 2)

- First phase
  - Bull's-eye rash; flulike symptoms
- Second phase
  - Irregular heartbeat; encephalitis; facial paralysis; memory loss
- Third phase
  - Arthritis due to an immune response
- Diagnosis via ELISA, indirect fluorescent-antibody (FA) test, or Western blot
- Treated with antibiotics
  - More difficult to treat in later stages

# Figure 25.14 The Common Bull's-Eye Rash of Lyme Disease



# Ehrlichiosis and Anaplasmosis

- **Human monocytotropic ehrlichiosis (HME)**
  - Caused by ***Ehrlichia chaffeensis***
    - Gram-negative, rickettsia-like, obligately intracellular
  - Form aggregates (**morulae**) in monocytes
  - Vector is the Lone Star tick; reservoir is the white-tailed deer
- **Human granulocytic anaplasmosis (HGA)**
  - Caused by ***Anaplasma phagocytophilum***
  - Vector is the ***Ixodes*** tick
- Both cause flulike disease
- Fatality less than 5%

# Typhus (1 of 4)

- Caused by **Rickettsia** spp.
  - Obligate intracellular parasites
  - Infect the endothelial cells of the vascular system
    - Block and rupture the small blood vessels
  - Spread by arthropod vectors

# Typhus (2 of 4)

- **Typhus fever** (epidemic louseborne typhus)
  - Caused by **Rickettsia prowazekii**
  - Carried by the body louse: **Pediculus humanus corporis**
  - Transmitted when louse feces are rubbed into the bite wound from the louse
  - Prolonged fever and a rash of red spots due to subcutaneous hemorrhaging
  - Treated with tetracycline and chloramphenicol

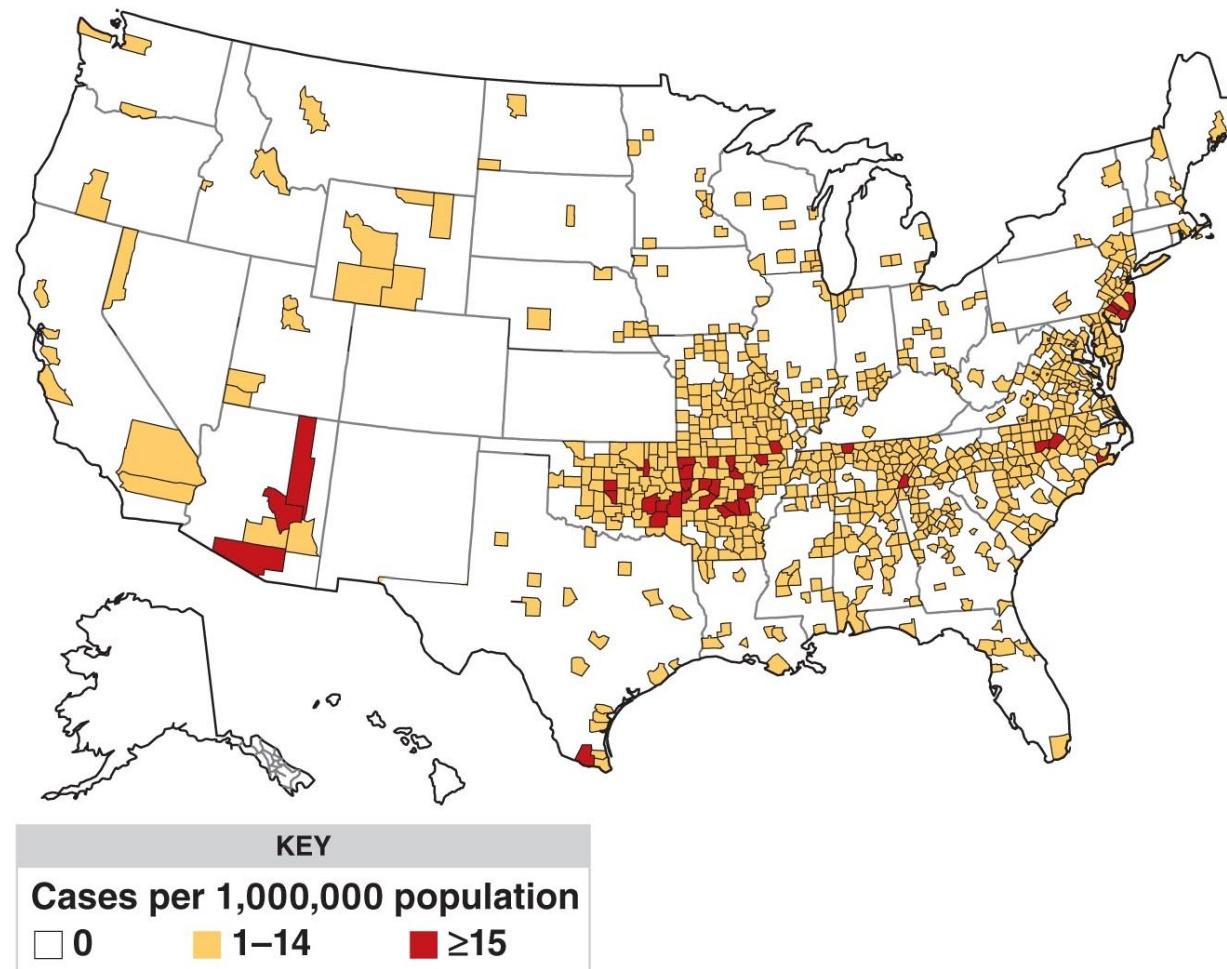
# Typhus (3 of 4)

- **Endemic murine typhus**
  - Caused by **Rickettsia typhi**
  - Transmitted by the rat flea: **X. cheopis**
  - Rodents (**murine** = mouse) are common hosts
  - Mortality rate less than 5%
  - Clinically indistinguishable from typhus fever
  - Treated with tetracycline and chloramphenicol

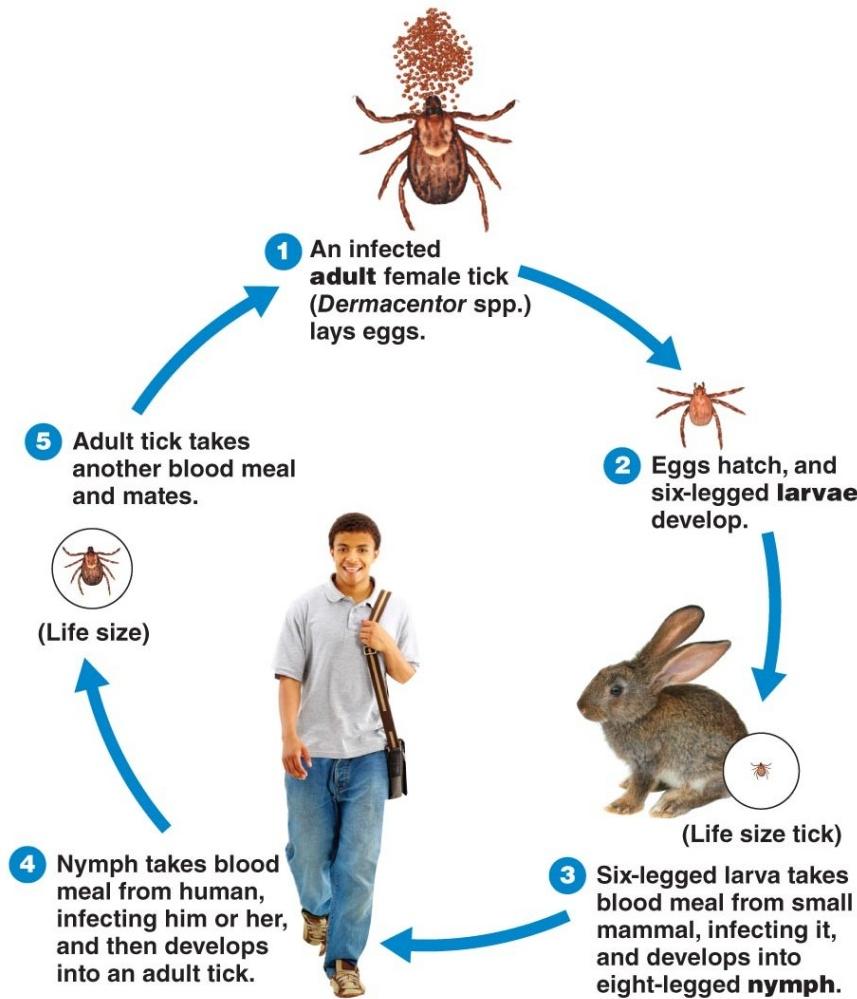
# Typhus (4 of 4)

- **Rocky Mountain spotted fever** (tickborne typhus)
  - Caused by **Rickettsia rickettsii**
  - Spread by wood ticks (**Dermacentor andersoni**) and dog ticks (**Dermacentor variabilis**)
  - Measles-like rash, except that the rash also appears on the palms and soles
  - Without early diagnosis, mortality rate is approximately 20%
  - Treatment with tetracycline and chloramphenicol

## Figure 23.15 The U.S. Geographic Distribution of Rocky Mountain Spotted Fever (Tickborne Typhus), 2011



# Figure 23.16 The Life Cycle of the Tick Vector (*Dermacentor* spp.) of Rocky Mountain Spotted Fever



# Figure 23.17 The Rash Caused by Rocky Mountain Spotted Fever



# **Check Your Understanding-9**

## **Check Your Understanding**

- ✓ Why is the plague-infected flea so eager to feed on a mammal?

23-10

- ✓ What animal does the infecting tick feed on just before it transmits Lyme disease to a human?

23-11

- ✓ Which disease is tickborne: epidemic typhus, endemic murine typhus, or Rocky Mountain spotted fever?

23-12

# Viral Diseases of the Cardiovascular and Lymphatic Systems

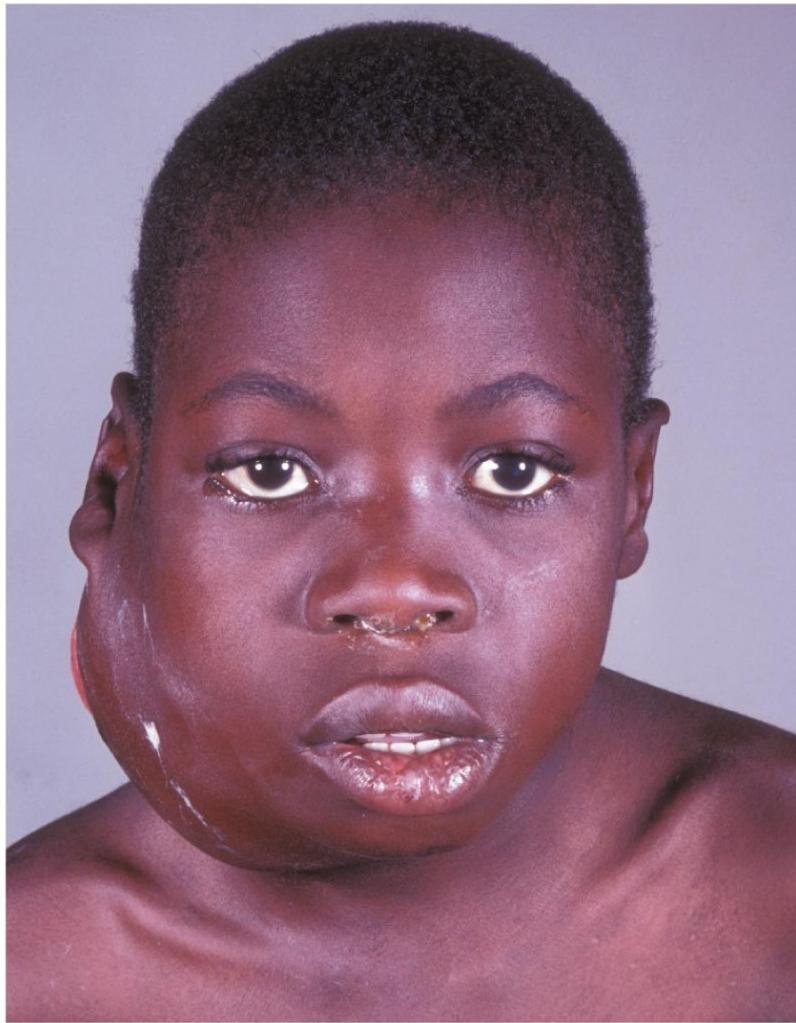
## Learning Objectives

- 23-13 Describe the epidemiologies of Burkitt's lymphoma, infectious mononucleosis, and CMV inclusion disease.
- 23-14 Compare and contrast the causative agents, vectors, reservoirs, and symptoms of yellow fever, dengue, dengue hemorrhagic fever, and chikungunya fever.
- 23-15 Compare and contrast the causative agents, reservoirs, and symptoms of Ebola hemorrhagic fever and **Hantavirus** pulmonary syndrome.

# Burkitt's Lymphoma

- Tumor of the jaw; most common childhood cancer in Africa
  - Due to Epstein-Barr virus (human herpesvirus 4)
- Malaria suppresses the immune system response to the virus

# Figure 23.18 A Child with Burkitt's Lymphoma



# **Check Your Understanding-10**

## **Check Your Understanding**

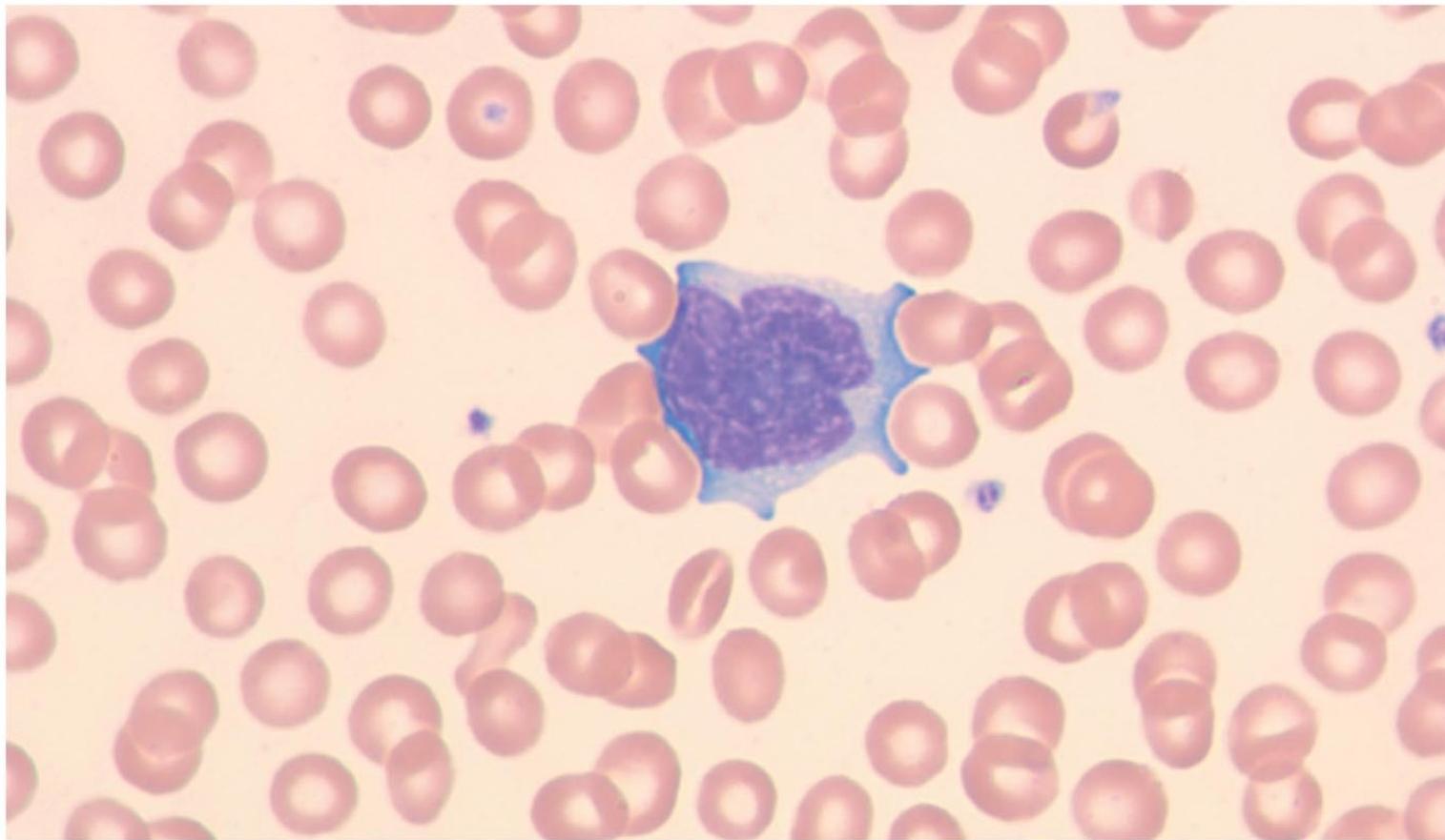
- ✓ Although not a disease with an insect vector, why is Burkitt's lymphoma most commonly a disease found in malarial areas?

23-13

# Infectious Mononucleosis

- Caused by Epstein-Barr virus
- Childhood infections are often asymptomatic
- Transmitted via saliva; incubation of 4 to 7 weeks
- Fever, sore throat, swollen lymph nodes, enlarged spleen
- Replicates in resting memory B cells
  - Form unusual lobed nuclei
  - Produce heterophile antibodies
    - Weak and multispecific

## Figure 23.20 A Lymphocyte with the Unusual Lobed Nucleus That Is Characteristic of Mononucleosis



LM | 10  $\mu\text{m}$

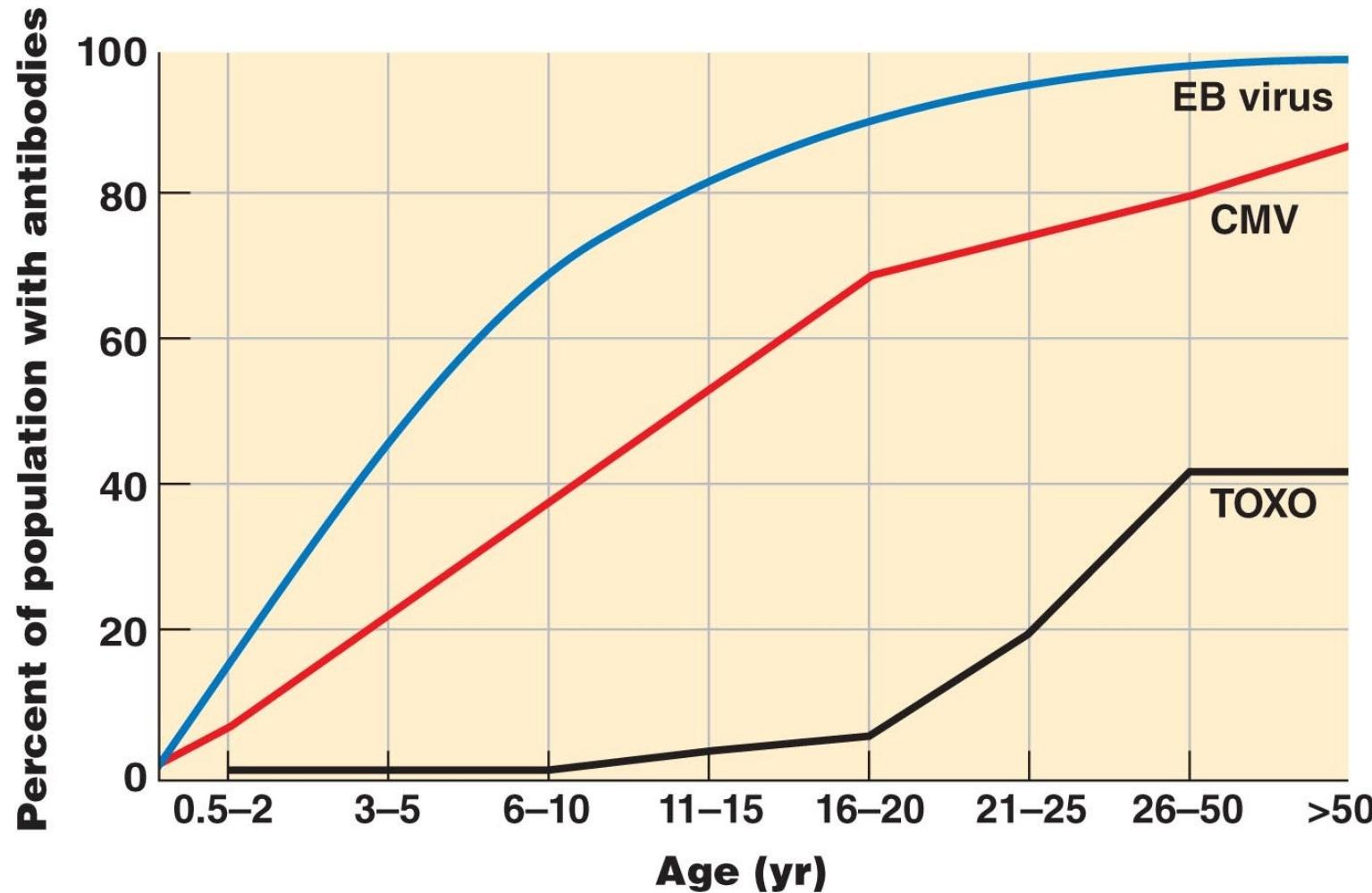
# Other Diseases and Epstein-Barr Virus

- Epstein-Barr virus associated with:
  - **Multiple sclerosis**
    - Autoimmune attack on the nervous system
  - **Hodgkin's lymphoma**
    - Tumors of the spleen, lymph nodes, and liver
  - **Nasopharyngeal cancer**

# Cytomegalovirus Infections

- Cytomegalovirus (human herpesvirus 5)
- Remains latent in white blood cells
- Infected cells swell
  - Form "owl's eyes" inclusions
- May be asymptomatic or mild in adults
- Cytomegalic inclusion disease (CID)
  - Transmitted across the placenta; causes mental retardation or hearing loss in newborns
- Transmitted sexually, via blood, saliva, or by transplanted tissue

## Figure 23.19 The Typical U.S. Prevalence of Antibodies Against Epstein-Barr Virus (EB Virus), Cytomegalovirus (CMV), and Toxoplasma Gondii (TOXO) by Age



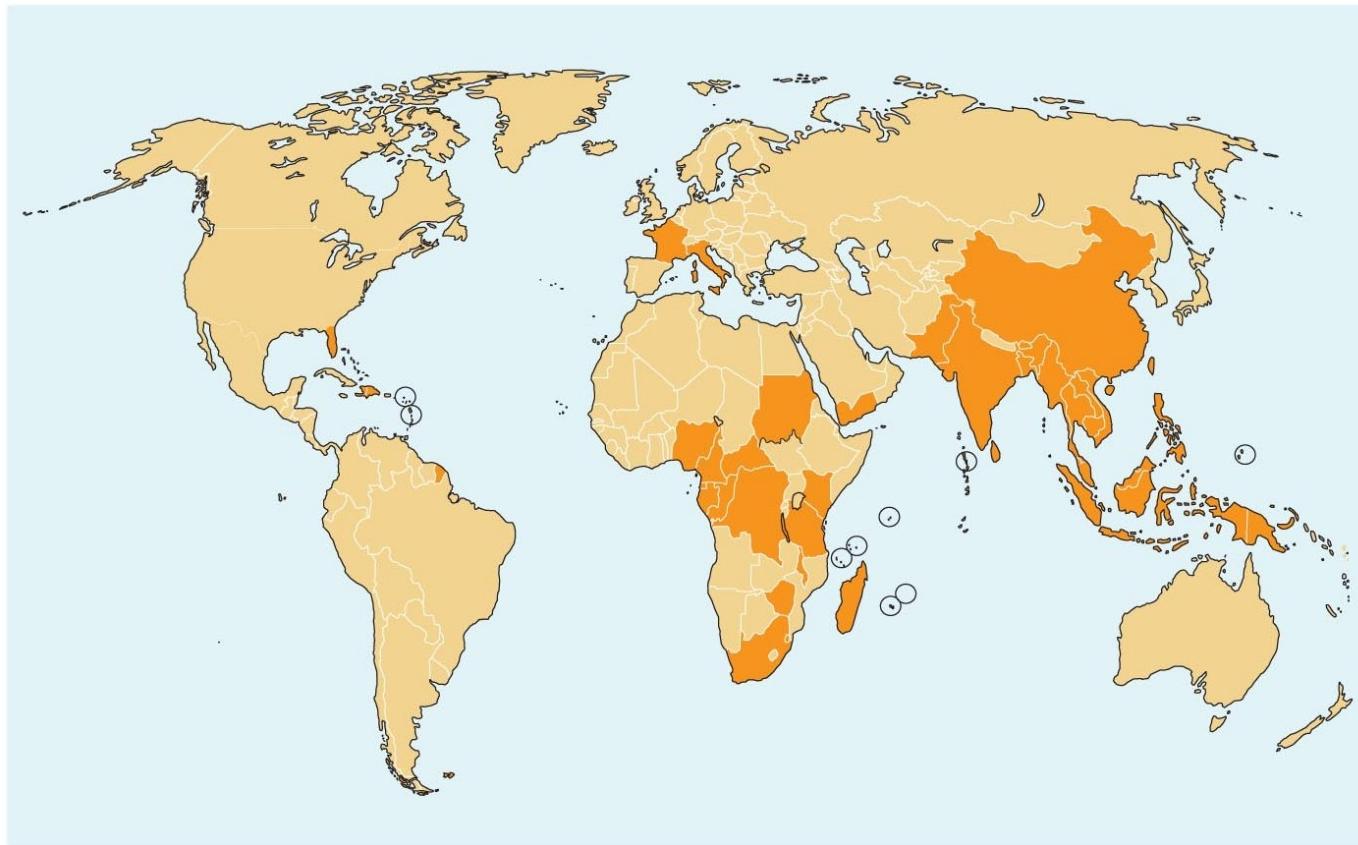
# Chikungunya Fever

- Chikungunya virus
  - Related to viruses causing western and eastern equine encephalitis
- Transmitted by **Aedes** mosquitoes
- High fever, severe joint pain, rash, blisters
  - Low death rate
- Introduced to the Western Hemisphere in 2013
  - Half a million cases in the Caribbean
  - Could soon become established in the United States due to the presence of the vector

# Big Picture: Climate Change and Disease (1 of 2)

- 2013: first indigenous case of chikungunya fever in the Western Hemisphere
- **Aedes albopictus**
  - Asian tiger mosquito
  - One of two vectors for chikungunya; feeds all day
  - Moving further north in the United States
    - Changing climate has expanded its habitat
    - Could occupy 50% of the United States by 2080

# Big Picture pg. 658



**Countries and territories where chikungunya cases have been reported  
(as of August, 2014). Source: CDC.**

# Big Picture: Climate Change and Disease (2 of 2)

- Challenges
  - Insecticides do not work well
  - Bed nets are ineffective because Asian tiger mosquitoes feed all day
- Some methods of control
  - Water storage covers
  - Ovitraps
  - Biological control
    - Mosquito dunks

# Big Picture pg. 659

## Common mosquito habitats around your home



**Eliminating sources of standing water is a main line of attack in controlling mosquito populations.**

**The illustration above shows common sources of standing water in homes.**

# Yellow Fever

- Yellow fever virus is injected into the skin from **Aedes aegypti**
- Fever, chills, headache, nausea, vomiting
- Jaundice due to liver damage
- Endemic in tropical areas
- No treatment; attenuated vaccine available

# Dengue and Severe Dengue

- Milder than yellow fever; transmitted by **A. aegypti**
- Endemic to the Caribbean and tropical environments
- Asymptomatic and mild (**dengue**) to severe bleeding and organ impairment (**severe dengue**)
- No animal reservoir
- No vaccine or effective drug treatment

# Check Your Understanding-11

## Check Your Understanding

- ✓ Why is the mosquito **Aedes albopictus** a special concern to the populations of temperate climates?  
23-14

# Emerging Viral Hemorrhagic Fevers (1 of 3)

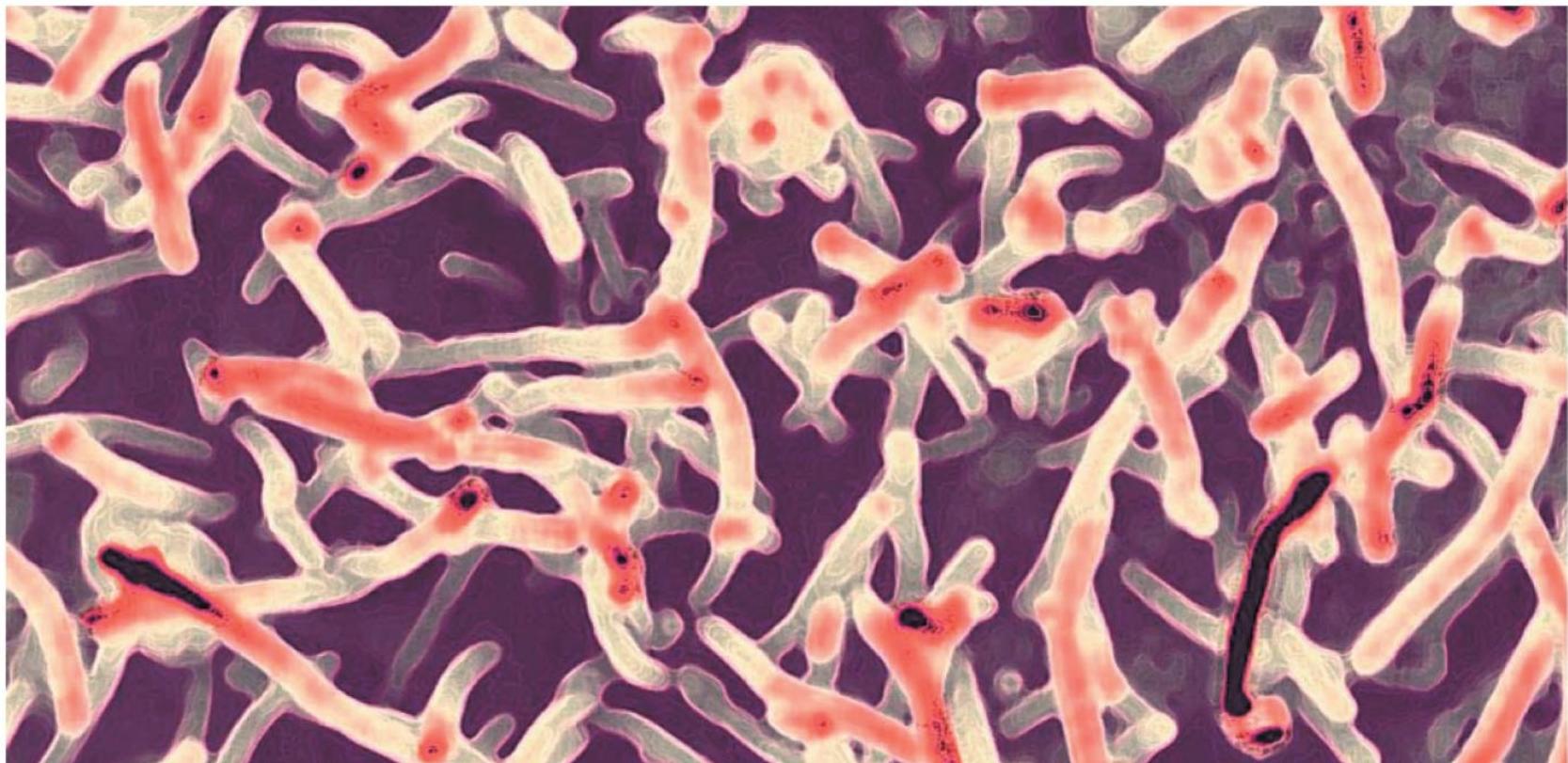
- **Marburg virus (green monkey virus)**
  - Transmitted from African monkeys
  - Headache, high fever, vomiting blood, profuse bleeding internally and externally
- **Lassa fever**
  - **Arenavirus;** found in rodent urine
  - Found in West Africa
  - Similar to **Argentine** and **Bolivian hemorrhagic fevers** (South America) and **Whitewater Arroyo virus** (California)

# Emerging Viral Hemorrhagic Fevers (2 of 3)

- **Ebola hemorrhagic fever**

- Caused by the **Ebolavirus**, a filovirus similar to the Marburg virus
- Reservoir is the cave-dwelling fruit bat near the Ebola River in Africa
- Spread by contact with infected body fluids
- Damages blood vessel walls and interferes with coagulation
  - Blood leaks into surrounding tissue
- Mortality rate of 90%

# Figure 23.21 Ebola Hemorrhagic Virus



SEM  
250 nm

# Emerging Viral Hemorrhagic Fevers (3 of 3)

- **Hantavirus pulmonary syndrome**
  - Caused by the Sin Nombre virus
  - Fatal pulmonary infection; lungs fill with fluids
  - Found in the western United States
  - **Hemorrhagic fever with renal syndrome**
    - Found in Asia and Europe
    - Affects kidney function

# Check Your Understanding- 12

## Check Your Understanding

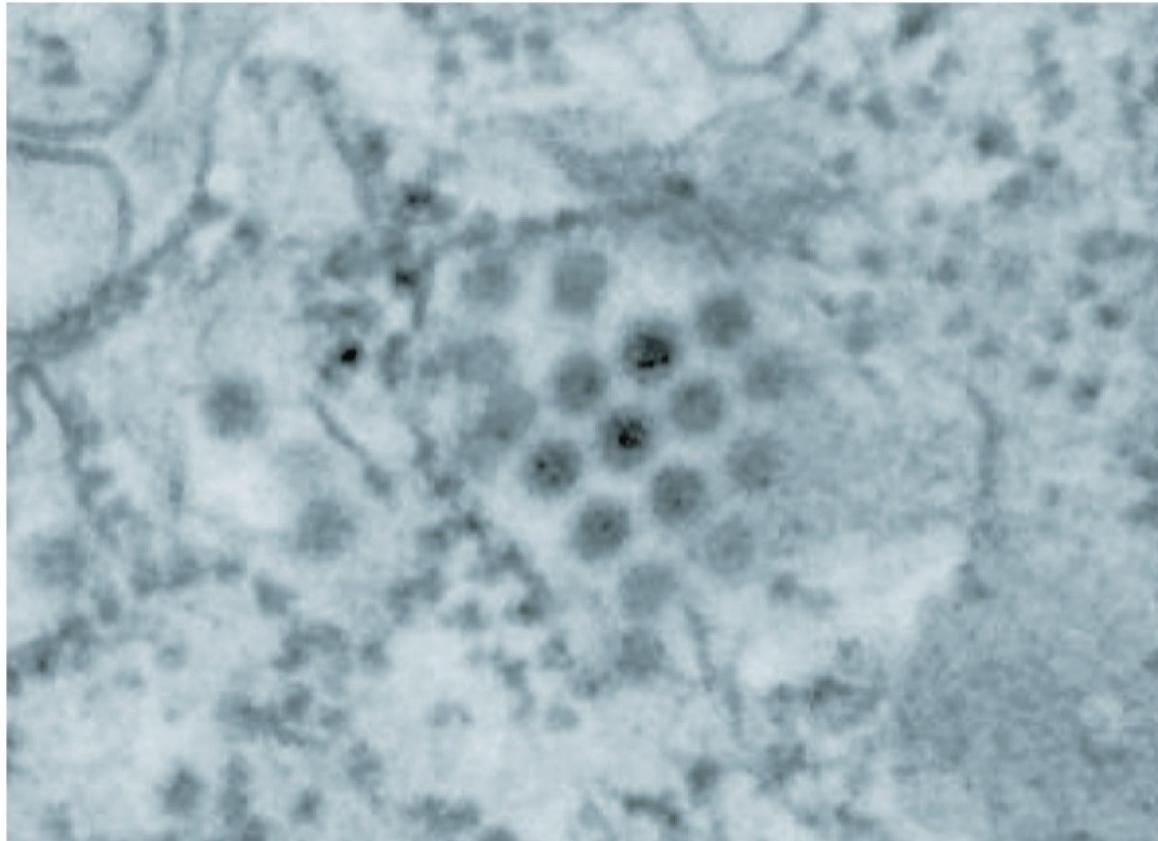
- ✓ Which disease does Ebola hemorrhagic fever more closely resemble, Lassa fever or **Hantavirus** pulmonary syndrome?

23-15

# Diseases in Focus: Viral Hemorrhagic Fevers

- What microbe could cause rash and severe joint pain in a 20-year-old woman?

# Diseases in Focus 23.4 (1 of 2)



TEM

100 nm

# Diseases in Focus 23.4 (2 of 2)

Disease	Pathogen	Portal of Entry	Symptom s	Reservoir	Method of Transmissi on	Preventi on
<b>Yellow Fever</b>	Flavivirus (yellow fever virus)	Skin	Fever, chills, headache; jaundice	Monkeys	<b>Aedes aegypti</b>	Vaccination; mosquito control
<b>Dengue</b>	Flavivirus (dengue virus)	Skin	Fever, muscle and joint pain, rash	Humans	<b>Aedes aegypti; A. albopictus</b>	Mosquito control
<b>Emerging Viral Hemorrhagic Fevers</b> (Marburg, Ebola, Lassa)	Filovirus, arenavirus	Mucous membranes	Profuse bleeding	Possibly fruit bats and other small mammals	contact with blood	None
<b>Hantavirus Pulmonary Syndrome</b>	Bunyavirus (Sin Nombre hantavirus)	Respiratory tract	Pneumonia	Field mice	Inhalation	None

# Protozoan Diseases of the Cardiovascular and Lymphatic Systems

## Learning Objectives

23-16 Compare and contrast the causative agents, modes of transmission, reservoirs, symptoms, and treatments for Chagas' disease, toxoplasmosis, malaria, leishmaniasis, and babesiosis.

23-17 Discuss the worldwide effects of these diseases on human health.

# Chagas' Disease (American Trypanosomiasis)

- Caused by **Trypanosoma cruzi**
  - Flagellated protozoan
  - Reservoir in rodents, opossums, and armadillos
- Vector is the reduviid bug (kissing bug)
  - Defecates trypanosomes into the bite wound of humans
- Chronic form of the disease causes megaesophagus and megacolon
  - Death due to heart damage
- Therapy is difficult due to trypanosome multiplying intracellularly

## Figure 23.22 *Trypanosoma Cruzi*, the Cause of Chagas' Disease (American Trypanosomiasis)

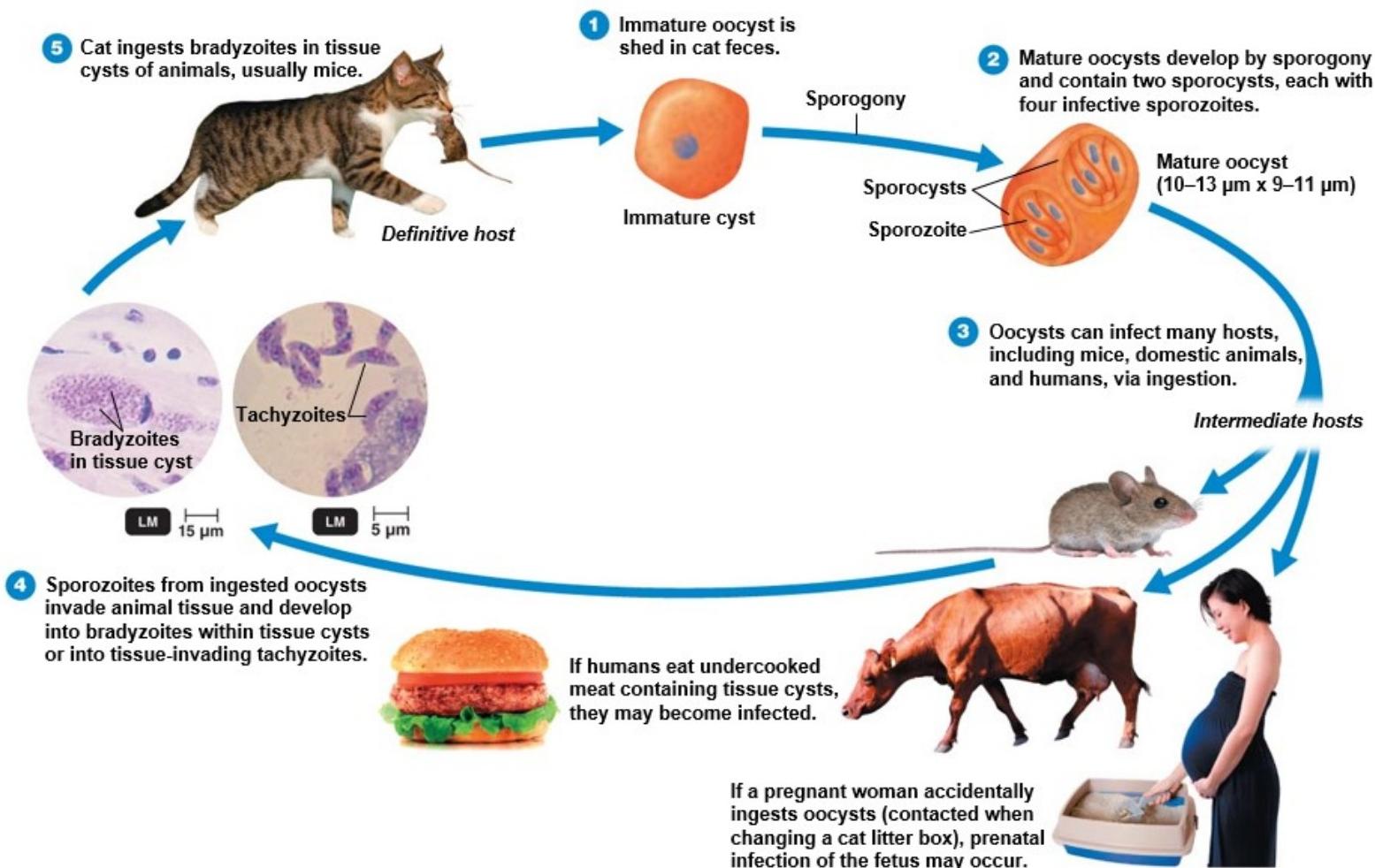


SEM  2.5  $\mu\text{m}$

# Toxoplasmosis

- Caused by **Toxoplasma gondii**
  - Undergoes its sexual phase in cat intestines
    - Oocysts shed in cat feces
- Contact with cat feces or undercooked meat introduces oocysts to the intestines
  - Oocysts form trophozoites that invade cells; may become a chronic infection
- Primary danger is congenital infection
  - Stillbirth
  - Neurological damage

# Figure 23.23 The Life Cycle of *Toxoplasma Gondii*, the Cause of Toxoplasmosis



# Malaria (1 of 3)

- Caused by **Plasmodium** parasites
- Transmitted by **Anopheles mosquitoes**
- Affects 300 to 500 million globally; 2 to 4 million deaths annually
- Four major forms:
  - **Plasmodium vivax**: mildest and most prevalent form; dormant in the liver
  - **Plasmodium ovale** and **Plasmodium malariae**: benign; restricted geographically
  - **Plasmodium falciparum**: most deadly; severe anemia; blocks capillaries; affects the kidneys, liver, and brain

# Figure 23.24 Malaria in the United States



## KEY



Malarial areas in 1912

Areas where malaria was endemic as recently as 1912

# Malaria (2 of 3)

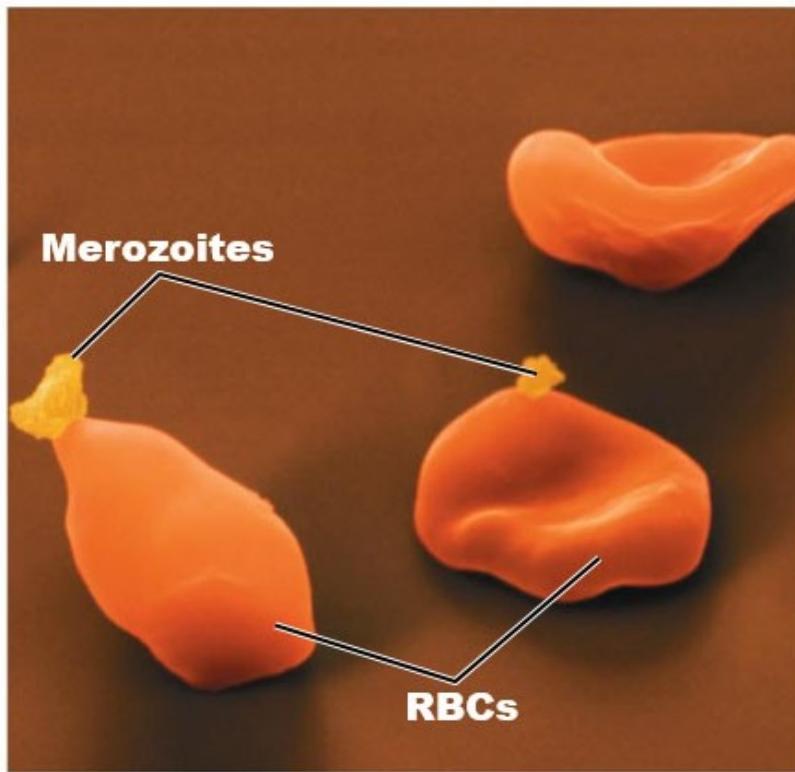
- Mosquito bite transmits sporozoite into the bloodstream
  - Enters the liver cells (which undergo schizogony), resulting in the release of merozoites into the bloodstream
- Merozoites infect RBCs and again undergo schizogony
  - Ruptures the infected RBCs, releasing toxic compounds
  - Causes paroxysms of chills and fever
- Some merozoites develop into gametocytes and are taken up by a mosquito, repeating the cycle



Pearson

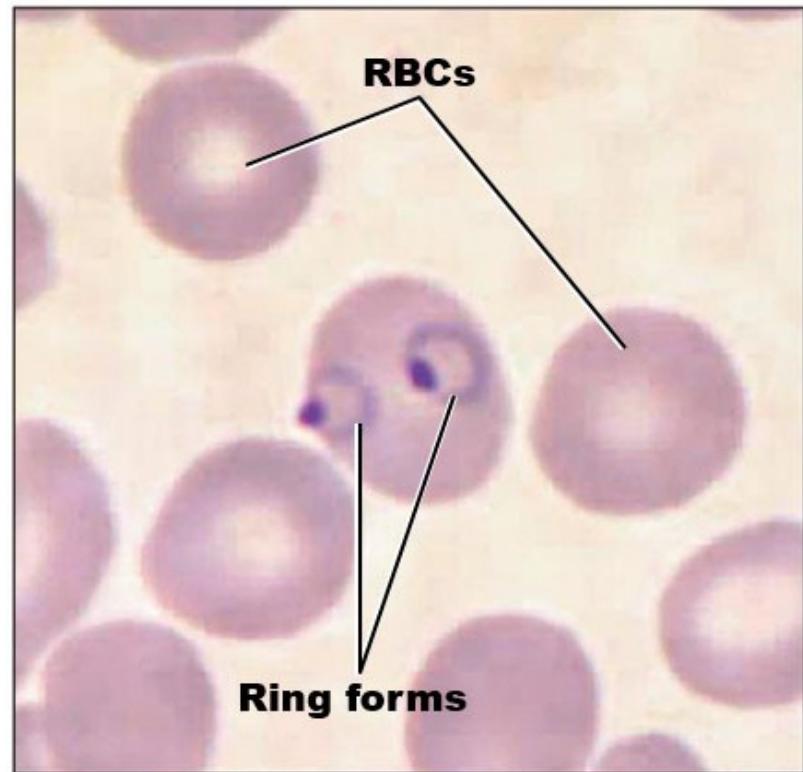
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# Figure 23.25 Malaria



**(a)** Merozoites being released from lysed RBCs

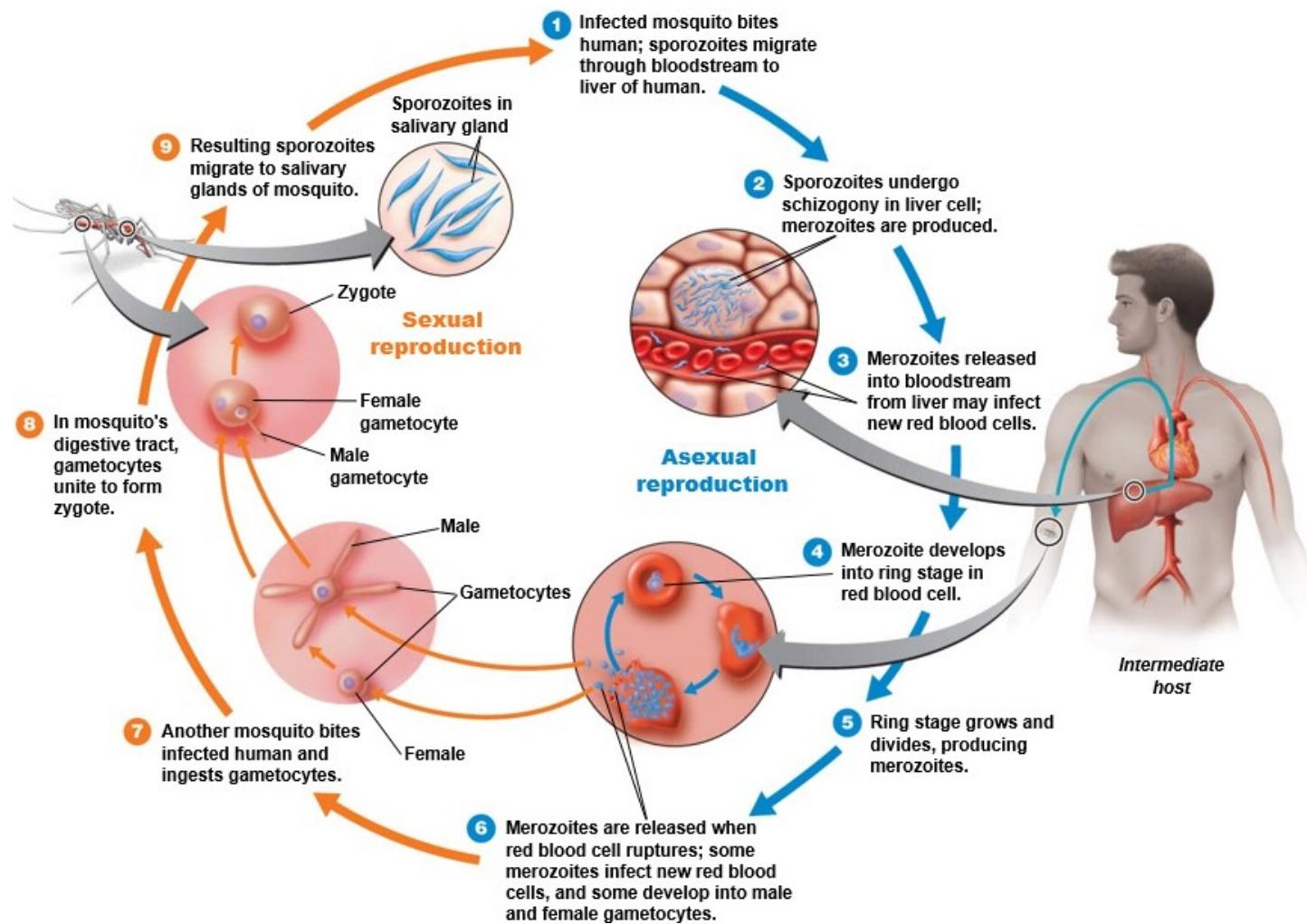
SEM  
1.5  $\mu$ m



**(b)** Malarial blood smear; note the ring forms.

LM  
1.5  $\mu$ m

# Figure 12.20 The Life Cycle of Plasmodium Vivax, the Apicomplexan That Causes Malaria



# Malaria (3 of 3)

- Difficult to develop a vaccine
  - **Plasmodium** rapidly mutates and evades an immune response
- Difficult to diagnose without sophisticated equipment
- Prophylaxis
  - Chloroquine; Malarone for chloroquine-resistant areas
- Treatment
  - Artemisinin
- Prevention
  - Bed nets



# Leishmaniasis

- Transmitted via female sandflies
  - Promastigote transmitted in saliva from bites
  - Amastigote proliferates in phagocytic cells
- **Leishmania donovani** (visceral leishmaniasis)
  - Invades the internal organs
- **Leishmania tropica** (cutaneous leishmaniasis)
  - Forms a papule that ulcerates and leaves a scar
- **Leishmania braziliensis** (mucocutaneous leishmaniasis)



# Figure 23.26 Cutaneous Leishmaniasis



# Babesiosis

- Caused by **Babesia microti**
- Carried by **Ixodes** ticks
- Resembles malaria
  - Parasites replicate in RBCs and cause fever, chills, and night sweats
- Treated with atovaquone and azithromycin

# **Check Your Understanding-13**

## **Check Your Understanding**

- ✓ What tickborne disease in the United States is sometimes mistaken for malaria when blood smears are inspected?

23-16

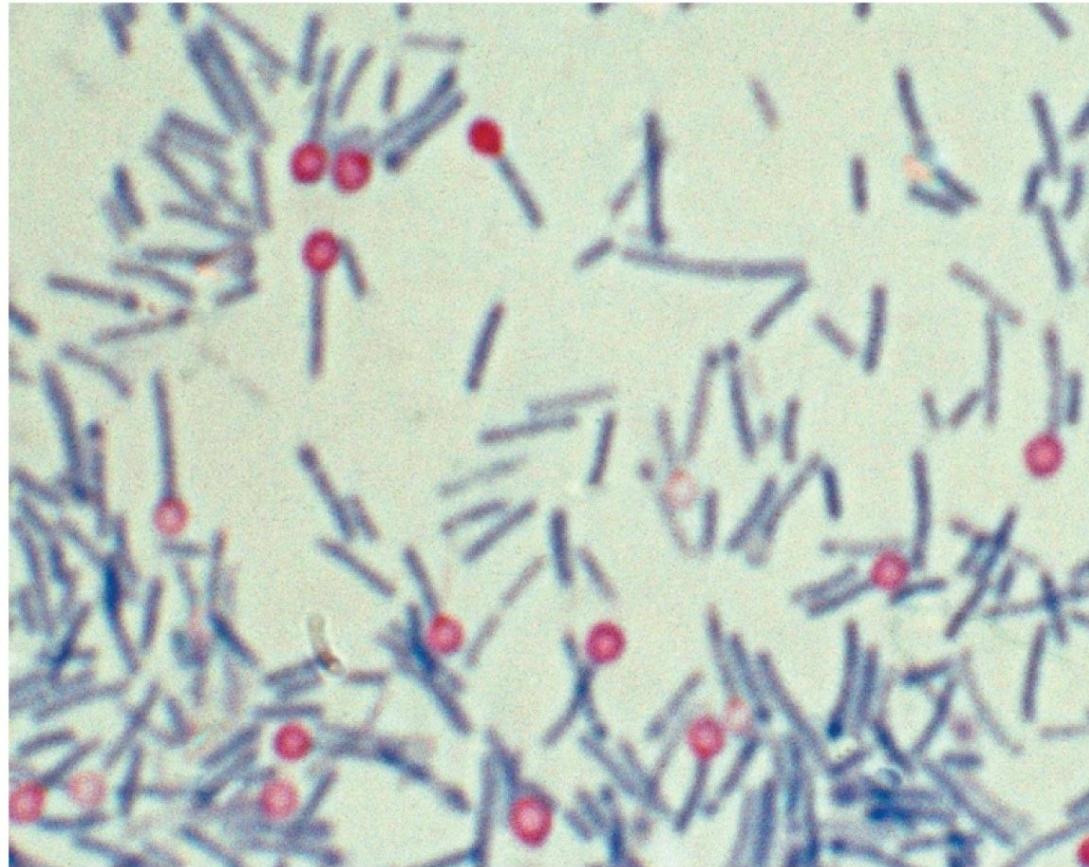
- ✓ Eliminating which of these diseases, malaria or Chagas' disease, would have the greater effect on the well-being of the population of Africa?

23-17

# Diseases in Focus: Infections Transmitted by Soil or Water

- A 65-year-old man with poor circulation in his legs develops an infection following injury to a toe.  
Dead tissue further reduces circulation, requiring amputation of two toes.
- What infection could cause these symptoms?

# Diseases in Focus 23.5 (1 of 2)



LM

2.5  $\mu\text{m}$

# Diseases in Focus 23.5 (2 of 2)

Disease	Pathogen	Symptoms	Reservoir	Method of Transmission	Treatment
<b>BACTERIAL DISEASE</b>					
Gangrene	<b>Gangrene <i>Clostridium perfringens</i></b>	Tissue death at infection site	Soil	Puncture wound	Surgical removal of necrotic tissue
<b>HELMINTHIC DISEASE</b>					
Schistosomiasis	<b><i>Schistosoma</i> spp.</b>	Inflammation and tissue damage at site of granulomas (e.g., liver, lungs, bladder)	Definitive host; humans	Cercariae penetrate skin	Praziquantel ; oxamniquine Prevention: sanitation; elimination of host snail

# Helminthic Disease of the Cardiovascular and Lymphatic Systems

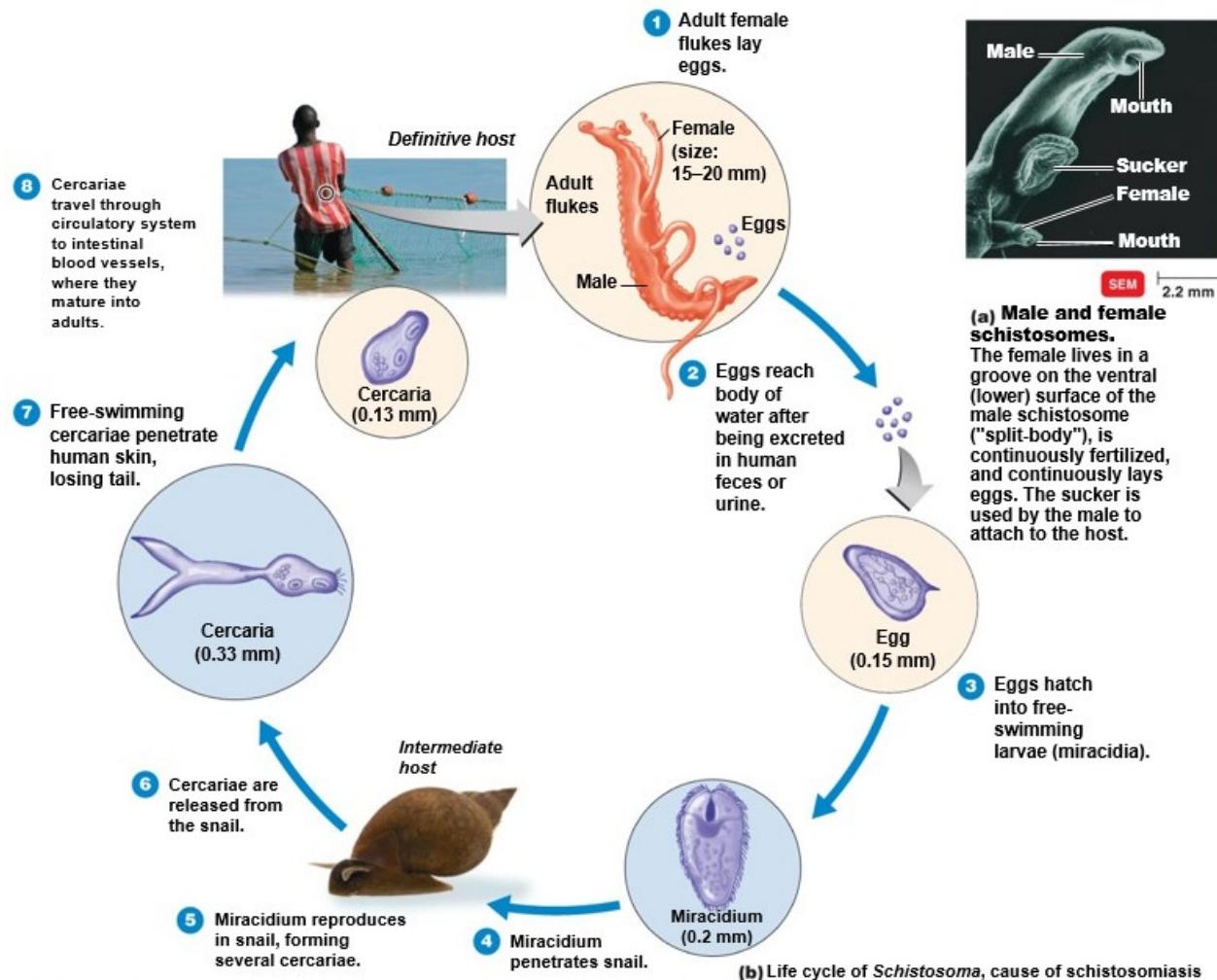
## Learning Objective

23-18 Diagram the life cycle of **Schistosoma**, and show where the cycle can be interrupted to prevent human disease.

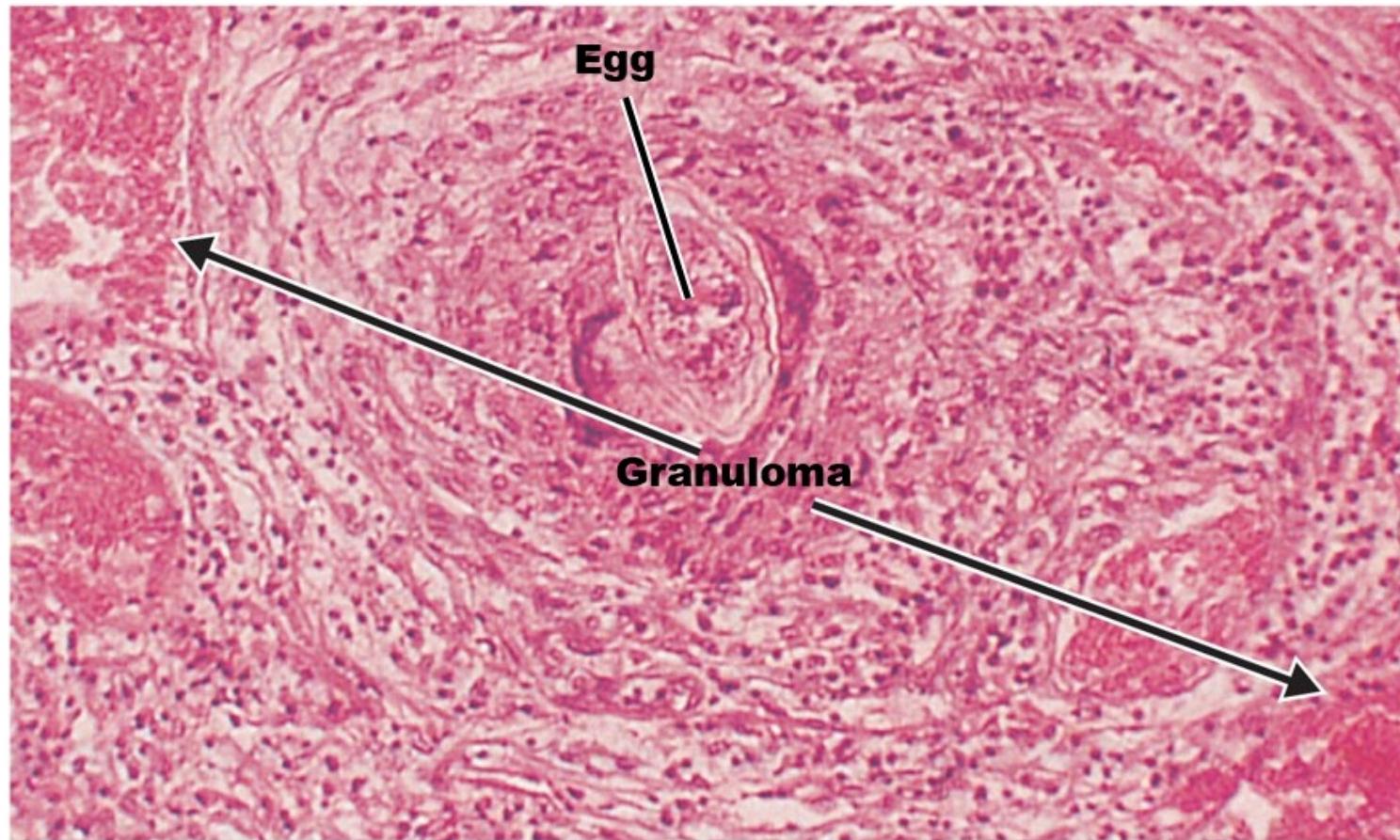
# Schistosomiasis

- Caused by small flukes called **Schistosoma**
  - Feces carrying eggs get into the water supply
    - Snails serve as the intermediate host
  - Cercariae released from the snail penetrate the skin of humans
  - Eggs shed by adult schistosomes in the host lodge in tissues, forming **granulomas**
- **Schistosoma haematobium:** urinary schistosomiasis
- **Schistosoma japonicum:** intestinal inflammation; found in Asia
- **Schistosoma mansoni:** intestinal inflammation;  
Found in South America

# Figure 23.27 Schistosomiasis



# Figure 23.28 A Granuloma from a Patient with Schistosomes



LM      0.1 mm

# **Check Your Understanding-14**

## **Check Your Understanding**

- ✓ What freshwater creature is essential to the life cycle of the pathogen causing schistosomiasis?

23-18

# Disease of Unknown Etiology

## Learning Objective

23-19 Recognize the clinical features of Kawasaki Syndrome.

# Kawasaki Syndrome

- Acute febrile illness of unknown etiology
- Most often affects younger children
- High fever, widespread rash, hand and feet swelling, swollen lymph glands
- Treated with aspirin
- Possible immunological cause

# **Check Your Understanding-15**

## **Check Your Understanding**

- ✓ What diseases of the cardiovascular and lymphatic systems need to be ruled out before a clinician can conclude that a patient has Kawasaki syndrome?  
23-19